MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 66, No. 10
W. B. No. 1251

OCTOBER 1938

CLOSED DECEMBER 3, 1938
ISSUED JANUARY 30, 1938

THE 1937 FREEZE IN CALIFORNIA

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[Weather Bureau, Pomona, Calif., October 1938]

The California citrus industry ranks second to petroleum as a basic source of wealth in the State. During the past 10 years it has returned to the State an average of $103,000,000 per year. The value of the crop delivered to the markets averaged $144,000,000 per year during the same period, an average of $41,000,000 per year being paid to the railroads for freight and refrigeration. Returns to the State in 1930 were $135,000,000 and the delivered value of the crop was $175,000,000. In 1929, a large crop year, the bill for freight and refrigeration was $54,000,000. The industry furnishes livelihood for 200,000 people in California, only half of them growers and their families, and is the principal support of many cities and towns in the fruit-growing districts.

More than one-half of the $41,000,000 annual freight bill is said to go directly to railroad labor for wages. Production of lumber and nails for boxes, paper wraps for the fruit, fertilizer, pest-control, and frost-protection supplies for the orchards employ other thousands. In 1937 the industry spent $30,000,000 directly as wages to labor, divided roughly, $23,000,000 in the groves and $7,000,000 to packing-house workers. Orchard supplies, including fertilizers, water, pest-control, and frost protection, cost $32,000,000 and packing-house supplies $10,000,000.

Crop failure from any cause spells disaster to whole communities and materially affects the prosperity of people far distant from California. Crop failures also result in higher prices for both California and Florida fruit to the consumer, the same amount of fruit costing many millions of dollars more than in years when fruit supplies are plentiful. During the earlier history of the citrus industry, before the development of orchard heating, not only the crops but the trees were subject to constant threat of damage or destruction by low temperature.

The climate of citrus growing sections in California is subtropical in general, but there are marked climatic differences between different districts. In interior districts most of the groves are located on the slopes of the lower foothills, but near the ocean there are large acreages located on almost level ground. Early experiences taught the growers not to plant citrus trees on the lowest ground in interior districts, although recently more and more plantings have been made in the colder sections, with reliance on orchard heating to prevent frost damage. Better soil and lower irrigation costs on the lower ground offset to some extent the greater costs of frost protection.

Frost protection [1] through orchard heating began in California about 1897, when a few growers began to burn coal in crude baskets made of chicken wire hung in trees. Protective methods improved and acreage equipped with heaters increased slowly until about 1913, and more rapidly thereafter. A survey made during the winter of 1937–38 showed 92,000 acres, or 29 percent of the total California citrus acreage, equipped with orchard heaters, requiring 2,860 carloads of oil for one filling. Oil storage tanks built exclusively for orchard heater oil in the citrus districts had a total capacity of more than 86,000,000 gallons.

Damagingly cold periods in California citrus districts are divided into two classes, frosts and freezes, but the classification of individual cold periods is sometimes difficult. True frosts are quite local in character, low temperatures being due mainly to radiational cooling after sundown. Range between day and night temperatures usually is large, sometimes as much as 60° F., strong temperature inversions build up during the night, and orchards located on hillsides are much warmer than those on the valley floor. Due to the strong temperature inversions near the ground, any wind of more than 4 miles per hour will cause an increase in surface temperature as a result of the mixing of relatively warm air at moderate elevations with the colder air in the orchards. Orchard heating under such conditions is very effective. Temperatures as low as 20° F. have been registered in citrus groves during purely local frosts.

Freezes are due mainly to the influx of great masses of cold air from the north or northeast, although radiational cooling after sundown also is an important factor. Freezes are more general than frosts, although in some small areas severe damage is usually prevented by wind, the effects of local topography, or proximity to the ocean. Diurnal temperature range is small, temperature inversions weak and shallow, and orchards in the foothills often are colder than those on the valley floor. Although extremely low temperatures seldom occur when wind continues steadily all night, the effectiveness of night winds in raising or preventing a fall in temperature usually is slight, due to weak temperature inversions. Maintenance of safe temperatures in the orchards through orchard heating usually is very difficult during freezes, due to air movement and weak inversions. Although local frosts cause some damage to citrus crops practically every winter, severe freezes occur only at intervals of 10 to 15 years. So disastrous have been the effects of past freezes that they stand out prominently in the history of the citrus industry.

While fragmentary accounts of early freezes have come down through the years, little or nothing is known of temperature or meteorological conditions accompanying

[1] See U. S. Department of Agriculture Farmers' Bulletin 1588, Frost and the Prevention of Frost Damage, for detailed information regarding frost protection methods.

them. In December 1891 a "great disaster" was reported, "preceded by a Santa Ana wind the like of which has never been seen before or since." Trees were described as glowing with phosphorescence, and "balls of fire leaped from tree to tree."[2] The winter of 1897–98 also is said to have been extremely cold.

On January 6, 7, and 8, 1913, occurred "the heaviest freeze since 1898," breaking all records for low temperature at a number of places in the State. The lowest temperature at Los Angeles equalled the previous record, and at San Diego a 64-year record for low temperature was broken. This freeze is the first about which there is any detailed meteorological information, although accurate orchard temperature records are almost entirely lacking.

The next freeze,[3] which occurred, January 19 to 24, 1922, was not so severe as that of 1913, but caused great damage to both fruit and trees. The crop was reduced by approximately 20,000 carloads, resulting in a loss of freight revenue to the railroads of about $10,000,000. Many individual growers not only lost all their fruit, but their orchards as well, although due to increased prices received for marketable fruit, the total return for the crop to California was only $12,000,000 less than for the previous season. Orchard heating proved so successful during this freeze that a great increase in protected acreage followed.

Another freeze occurred in 1924, but its severity was much less than the freezes of 1913 and 1922. On December 9 to 15, 1932, an extremely heavy freeze occurred in Sacramento Valley citrus districts, in the northern part of the State, with orchard temperatures as low as 10.5° F. registered in the coldest groves, but it failed to reach the southern part of the State. A series of unusually mild winters followed up to and including the winter of 1935–36.

On the basis that severe freezes had occurred in the past every 10 to 15 years, fruit growers were warned repeatedly in published articles and at public gatherings that the mild weather of 1936 should not cause them to relax their vigilance, and that a severe freeze actually was overdue. Weather Bureau surveys had shown an alarming deficiency in orchard heater fuel storage facilities for carrying through a freeze, and every possible effort was made to acquaint the public with the seriousness of the situation. The danger was strongly emphasized in 9 different articles published in grower magazines as well as in frequent newspaper articles, and also was brought directly to the attention of growers and packing-house managers at more than a hundred meetings called to discuss orchard heating problems. These efforts resulted in an increase of nearly 20,000,000 gallons in oil-storage-tank capacity in the citrus districts, but statistics showed total heater oil storage to be still far short of minimum safety requirements. Officials of cooperative purchasing organizations charged with the responsibility of securing fuel for the growers therefore awaited the inevitable freeze in a far from tranquil state of mind.

The month of November 1936 was warm, with but one light frost and only light scattered orchard heating for lemons in one small area. Light to moderate frosts were frequent during December, with some orchard heating necessary on 5 nights. From the night of December 31 to the night of February 1 moderate to heavy frost occurred at some point in the citrus growing districts on all but two dates.

The first definite indication of an impending freeze was noted on the weather chart for January 4, and advisory warnings were given to packing-house managers. On January 5 packing-house managers were urged to fill up all orchard heater oil storage tanks and to make all other necessary preparations for a freeze. This warning was amplified on the 6th and given wide distribution to railroads, oil companies, etc. A severe freeze, comparable to the freeze of 1922, was forecast.

Supplies of orchard heaters in Pacific Coast warehouses were exhausted within a few hours after the first warning was made public. Many orchards, including one owned by the State of California at Whittier, were protected throughout both January freezes with heaters purchased, transported to the groves and filled with oil between the time of the first warning and the beginning of the first freeze. Wherever possible mature fruit was hurriedly picked from trees and hauled to packing houses, although in Tulare County and some other localities fruit could not be picked because of rain which immediately preceded the freeze.

A vigorous low-pressure area centered over northwestern Washington on January 4 moved rapidly south-southeastward, reaching northern Arizona on the evening of the 6th, bringing moderate to heavy rains to all of California. Cold polar-continental air followed in its wake, reaching northern California on the morning of the 7th and the Imperial Valley on the night of the 8th. The only citrus districts to feel the effects of the freeze on the night of the 6th–7th were those in the Sacramento Valley. Temperatures there held up well until morning, but dropped to 23° F. between 5 a. m. and sunrise. The freeze spread to the San Joaquin Valley on the following night and began to be felt in all southern California districts except the Imperial Valley, which was not reached until the night of the 8th–9th. Generally speaking, the night of the 8th–9th was the most severe of the entire cold period, although the freeze continued until the night of the 10th–11th, and temperatures in some districts were as low on the 9th–10th as on the preceding night. Snow which fell in the Redlands district on the night of the 6th remained on the ground in foothill orchards until the 11th. Notes on the individual nights of this freeze are given below for different districts.

January 6–7, 1937

Sacramento Valley district.—Clear; strong north wind slackened between 5:00 and 7:00 a. m. with rapid temperature fall from 27° to 23°. Heavy firing for lemons began about 11:30 p.m.

January 7–8, 1937

Sacramento Valley district.—Ice on puddles increased in thickness all day. Clear; strong northerly wind all night, despite which the temperature fell to 18° in spots. Heavy firing began at 11 p. m.

San Joaquin Valley district.—Clear; heavy general firing began before 7 p. m. Lowest temperature in district 18°; average minimum all stations 24°.

Santa Paula district.—Clear except for a few clouds at intervals. Considerable wind over most of the district, with most stations registering minimum temperatures between 30° and 33°. Scattered moderate firing began about 10 p. m. Lowest temperature 25°.

Southern California.—Considerable broken cloudiness during the day, with rain squalls near the mountains. Considerable cloudiness during the early part of the night, varying in different districts: Moderate firing began between midnight and 2 a. m. in the Azusa, Pomona, Upland, and Redlands districts, and in the Los Angeles County portion of the Whittier-Orange County district. No firing in central and southern Orange County, and only light, scattered firing after 5 a. m. in the Corona district. Temperatures in the Imperial and Coachella Valleys remained above freezing all night. Lowest temperatures by districts: Whittier 25°; Azusa, Upland, and Corona 24°; Pomona 23°; Redlands 22°.

[2] Static electrical effects due to high wind velocity and extremely low humidity.
[3] See "Notes on the 1922 Freeze in Southern California," MONTHLY WEATHER REVIEW November 1923, pp. 581–585.

January 8–9, 1937

Sacramento Valley district.—Clear; moderate to fresh northerly wind died out completely about 1:20 a. m., after which temperature fell rapidly from 27° to 15.5° at 5:30 a. m. Heavy firing after midnight.

San Joaquin Valley district.—Clear; heavy general firing began before 7 p. m. Lowest temperature in district 18°.

Santa Paula district.—Clear; wind over most of district held temperatures near or above 32° at most stations. Heavy firing began in sections sheltered from the wind about 7:30 p. m. Lowest temperature in district 21°.

Southern California.—Clear to partly cloudy during day; clear all night. Wind kept temperature above danger point in Orange County from Fullerton south to Anaheim, Orange, and Santa Ana, and caused strongly fluctuating temperature in all other sections. Heavy general firing began between 6 p. m. and 7 p. m. in the Pomona, Upland, Azusa, and Redlands districts, and in the Los Angeles County portion of the Whittier district, northern and extreme southern Orange County. Moderate general firing began in the Corona district about 10 p. m. Lowest temperatures by districts: Whittier, Azusa, Pomona, and Upland 22°; Corona 21°; Redlands 18°.

Imperial and Coachella Valleys.[4]—Partly cloudy in early evening; clear thereafter. Lowest temperature in district 19°.

January 9–10, 1937

Sacramento Valley district.—Overcast sky all night. Snow began to fall about 4 a. m. and continued for about 42 hours. Amounts varied from 1 to 3 inches in vicinity of Oroville and Woodland to 15 to 18 inches in vicinity of Orland and Hamilton City. In the latter districts the fall was the heaviest ever recorded there. Lowest temperature in district 27°.

San Joaquin Valley district.—Clear; heavy general firing over entire district, beginning about 8 p. m. Lowest temperature 20°.

Santa Paula district.—Clear, scattered moderate to heavy firing in spots, beginning about 7:30 p. m. Wind held temperature above 32° at many points. Lowest temperature in district 20°.

Southern California.—Clear sky day and night. Wind held temperatures above the danger point in Placentia, Yorba Linda, Fullerton, and Anaheim sections, and caused widely fluctuating temperatures in most other districts. Moderate to heavy general firing in areas sheltered from the wind began about 5 p. m. in the Upland district, 6:30 p. m. in the Azusa, Pomona, and Redlands districts, 8 p. m. in the Whittier district, and 10 p. m. in the Corona district. Lowest temperatures by districts: Pomona, Azusa, and Whittier 23°; Upland 22°; Corona 21°; Redlands 19°.

Imperial and Coachella Valleys.—Clear; lowest temperature in district 21°.

January 10–11, 1937

Sacramento Valley district.—Overcast; snow continuing; lowest temperature 32°.

San Joaquin Valley district.—Lowest temperature 24°; no firing.

Santa Paula district.—Clear; light to heavy firing in a few small areas, beginning about 8 p. m. Temperature remained above 32° over most of district. Lowest temperature 22°.

Southern California.—Considerable cloudiness in the Whittier district and some intermittent cloudiness in other sections, during the early part of the night. Temperatures were much lower in the interior than near the coast. Light scattered firing began on low ground in the Azusa section about 8:30 p. m. Moderate scattered firing began in the Pomona and Upland districts about 7 p. m. Moderate general firing began in the Corona district about 8 p. m., in southern Orange County about 10:30 p. m., and in the remainder of the Whittier district about 2:30 a. m. Heavy general firing began in the Redlands district about 7 p. m. Lowest temperatures by districts: Whittier 26°; Pomona and Azusa 24°; Corona 23°; Upland 22°; Redlands 21°.

Imperial and Coachella Valleys.—Clear sky; lowest temperature 22°.

EFFECTS OF FREEZE OF JANUARY 7–11, 1937

Orchard heating in the Sacramento Valley was unusually difficult due to the strong winds which continued most of the time on the coldest nights. In one lemon orchard the fruit was abandoned after the first cold night, and heaters were lighted thereafter only for the protection of the trees. In the largest lemon orchard in the district, however, heavy firing carried most of the crop through the cold period without damage. Practically all lemon trees in the district were protected, and damage to orange trees was negligible. The last of the orange crop was hurriedly harvested before the freeze began.

In the San Joaquin Valley the freeze left all unheated lemons and Valencia oranges a complete loss as fresh fruit, but with a considerable portion thought to be of some value for byproduct manufacture. Navel oranges suffered slight to moderate damage in unprotected groves. Unprotected lemon trees suffered heavy defoliation, but damage to orange and grapefruit trees was confined to late fall growth as a general rule. There was no damage to fruit or trees in groves with standard heating equipment efficiently handled.

South of the Tehachapi Mountains all varieties of fruit were protected without difficulty in groves with adequate orchard heating equipment and fuel supply. Fuel for heaters designed to burn carbon briquets or petroleum coke became increasingly difficult to obtain as the freeze progressed, and by January 9 was almost unobtainable. Reserves at manufacturing plants had been entirely exhausted, and only the daily output of briqueting plants was available. More than 600 trucks and other vehicles waited in line for solid fuel as long as 48 hours. In desperation growers turned to wood, coal, discarded rubber tires, scrap rubber from manufacturing plants, peach and olive pits, and even hay and straw for orchard heating fuel. One large orchard burned nothing but bailed alfalfa hay throughout one night, expensive but effective in saving tender lemon trees.

Orchard heater oil held out better than solid fuel, but by January 10 many growers received desperately needed oil supplies after nightfall and were forced to fill and light the heaters simultaneously. A few growers lost their crops on this night because of inability to secure fuel.

The second and more severe freeze of the winter arrived before the amount of damage caused by the first freeze could be determined accurately. Estimates placed the damage at 15 percent to Navel oranges and lemons and 18 percent to Valencia oranges and grapefruit. With the exception of lettuce, vegetable crops in the Imperial and Coachella Valleys suffered heavy damage. Although this freeze caused extensive damage to avocado trees and tropical plants, damage to citrus trees south of the Tehachapi Mountains was almost negligible.

SECOND FREEZE OF JANUARY 1937

A period of cool cloudy weather, with frequent rains, followed the termination of the first January freeze. Fruit growers had hardly recovered from their exhaustion following the battle to save the crop when on the morning of January 18 it became apparent that a second freeze was imminent. A barometric depression moved rapidly southward from northwestern Canada, increasing in intensity, followed by another influx of polar air. On that date all packing-house managers were warned of the approach of another severe freeze which would necessitate several nights of heavy general firing of orchard heaters. Refilling of oil storage tanks, emptied during the first freeze, had been discouragingly slow, due largely to a feeling on the part of the growers that two severe freezes could not occur during the same winter. No basis for such a belief existed, since two severe freezes had arrived about a week apart in January–February 1922. In a few cases it was necessary to use the strongest possible measures to convince local cooperative association managers who were negotiating for lower oil prices, of the seriousness of the situation.

[4] Practically no orchard heaters used in this district. Some protection obtained through running irrigation water in orchards and truck crop areas, and covering truck crops with brush, paper, tules, etc.

No such difficulty was experienced in dealing with central cooperative purchasing organizations, oil companies, or the railroads. Every agency for the expedition of orchard heater fuel transport was instantly mobilized and all possible preparations were made for the second battle with the cold. Special railroad switching crews were placed in railroad yards near oil refineries to expedite movement of tank cars, special crews for loading cars were gathered, and every motor truck equipped for fuel transportation was placed in service.

The first effects of the new freeze were felt on the night of January 19–20 simultaneously throughout the length of the California citrus belt, but there was considerable intermittent cloudiness during the night in all sections but the Sacramento Valley, and temperatures in general outside that section did not fall very low. On the morning of the 20th a warning was given the widest possible distribution that the freeze would bring the lowest temperatures in 24 years to southern California, and efforts to prevent failure of fuel supplies were redoubled. Generally speaking, the night of January 20–21 was the coldest in northern and central California districts, while the following night was coldest in southern districts. Day-by-day notes on the freeze by districts are given below.

January 19–20, 1937

Sacramento Valley District.—Clear; moderate to fresh north wind, decreasing in velocity at times after midnight. Heavy firing for lemons began about 11 p. m., and continued until 9:30 a. m. Despite protective efforts all lemons brought through the first freeze undamaged were badly frozen. Lowest temperature, 18°.

San Joaquin Valley District.—Considerable cloudiness during the first part of the night. Scattered light firing began about midnight. Lowest temperature, 25°.

Santa Paula District.—Some cloudiness at intervals, and intermittent wind in spots during the night. Quite general light to heavy firing over the district, although temperatures remained above the danger point in some localities. Lowest temperature, 22°.

Southern California.—Some cloudiness at intervals in all sections during the night, heaviest in Orange County. Moderate to heavy general firing began about 7 p. m. in Pomona and Upland districts, about 8 p. m. in Corona and Redlands, and 9 p. m. in Azusa. Moderate firing began in the Whittier district about 10:30 p. m. north of Orange. No heaters were lighted south of Orange. Lowest temperatures by districts: Whittier, Azusa, and Pomona, 24°; Corona and Upland, 22°; Redlands, 21°.

Imperial and Coachella Valleys.—Wind and clouds maintained safe temperatures over practically the entire district. Lowest temperature, 26°.

January 20–21, 1937

Sacramento Valley District.—Clear; moderate to fresh north wind practically all night in Maxwell lemon-growing district maintained temperatures above the danger point for trees, and since all fruit had been frozen, heaters were not lighted. Some firing after midnight for orange trees near Hamilton City. Lowest temperature in district, 15°.

San Joaquin Valley District.—Clear. General heavy firing began before 7 p. m. All unprotected fruit in district which might have escaped damage in first January freeze destroyed on this night. Fruit damage in lemon and orange groves equipped with orchard heaters varied from zero to heavy, depending on equipment, efficiency of firing, and location. Complete defoliation of practically all unprotected lemon trees; some defoliation in many heated lemon groves. Unprotected orange and grapefruit trees 50 percent defoliated in small areas, chiefly in southern portion of district; large areas showed no defoliation. Heaviest defoliation in areas with highest average winter minimum temperature. Lowest temperature in district, 14°, the lowest official temperature recorded since establishment of Fruit-Frost Service in November 1922.

Santa Paula District.—Some cloudiness and considerable wind in open sections during night. Light to heavy general firing began about 7 p. m., although minimum temperatures over most of the district ranged from 28° to 31°. Lowest temperature in district, 21°.

Southern California.—Considerable cloudiness up to midnight in all areas, continuing in some sections until nearly morning. Wind prevented temperature fall in some sections until 4 a. m., after which there was a sudden drop, which caught many growers napping and resulted in some damage in fired groves. Light scattered firing began in Pomona, Upland, and in the western portion of the Whittier district from 8 p. m. to 8:30 p. m., becoming heavy between 4 a. m. and 6 a. m. Moderate general firing began in the Corona district about 1 a. m. and in the Azusa district at 4:30 a. m. Heavy general firing began in the Redlands district about 2 a. m. No firing in Whittier district south of Orange. Lowest temperatures by districts: Whittier, 22°; Upland, Pomona, Azusa, and Corona, 21°; Redlands, 16°.

Imperial and Coachella Valleys.—Wind and clouds at intervals. Lowest temperature, 25°.

January 21–22, 1937

Sacramento Valley District.—Clear until arrival of some altocumulus clouds about 2:30 a. m. Very little wind; temperature fell to 21° by 10:30 p. m. Firing for lemon trees began about 11:30 p. m. Lowest temperature, 18°.

San Joaquin Valley District.—Clear; general heavy firing began before 7 p. m. Lowest temperature, 17°.

Santa Paula District.—Clear sky; less wind than previous night, but sufficient in a few open areas to hold temperature up to 30° to 32°. Light to heavy general firing, depending on location, began about 8 p. m. and continued until 10 a. m. Lowest teperature in district, 18°.

Southern California.—Clear; considerable wind in some areas before midnight, but little thereafter. Temperature dropped 11° in a half hour in southern Orange County when wind lulled. Moderate to heavy general firing began 4 p. m. to 6:30 p. m. in Upland, Redlands, Pomona, Azusa, and northern portion of Whittier district; 9:30 p. m. in Fullerton-Placentia section; 11 p. m. in Corona and southern portion of Whittier district. Lowest temperatures by districts: Azusa, 21°; Pomona, 20°; Upland and Whittier, 19°; Corona and Redlands, 16°.

Imperial and Coachella Valleys.—Clear; north wind died out in early evening. Lowest temperature, 12°.

January 22–23, 1937

Sacramento Valley District.—Clear; northerly wind during most of the night, with rapid temperature fall during lulls. Light firing for tree protection only began about 4 a. m. Lowest temperature, 20°.

San Joaquin Valley District.—Clear except for a few high clouds at long intervals. General heavy firing began about 7:30 p. m. Lowest temperature, 16°.

Santa Paula District.—Considerable cloudiness during early part of night. Although firing probably was more general throughout the district on this night than any other during the freeze, minimum temperatures ranged from 29° to 36° at many points due to wind. Light to heavy firing, depending on location, was fairly general after about 10 p. m. Lowest temperature in district, 22°.

Southern California.—Overcast sky all day. Clouds began to break between 8:30 p. m. and 10:30 p. m., and sky was clear in all sections by 11 p. m. Considerable wind in some sections, notably in parts of Orange County. Lowest temperatures were well above the danger point in the vicinity of Anaheim, Olive, and Yorba Linda. Moderate to heavy general firing began about 6 p. m. in Upland and Pomona districts; 7 p. m. in Azusa; 8 p. m. in Redlands and northern portion of Whittier district; and 11:30 p. m. in Corora and the southern portion of the Whittier district. In several sections the temperature dropped below the danger point while the sky was still overcast with low clouds. Lowest temperatures by districts: Whittier, 22°; Upland, Pomona, and Azusa, 20°; Corona, 18°; Redlands, 15°.

Imperial and Coachella Valleys.—Cloudy first part of night; clear during latter part. Little wind. Lowest temperature, 12°.

January 23–24, 1937

Sacramento Valley District.—Cloudy during most of the night. No firing. Lowest temperature in district, 26°.

San Joaquin Valley District.—Clear sky until toward morning. General heavy firing began about 7 p. m. Lowest temperature in district, 22°.

San Paula District.—Clear sky except for a few clouds at long intervals. Considerable wind in some areas, holding temperature at 32° in spots. Moderate to heavy general firing, except in windy areas, began about 7:30 p. m. Lowest temperature, 22°.

Southern California.—Clear all night in inland districts, but considerable cloudiness in districts nearest the ocean before morning. Cloudiness began in the Whittier district about 2:30 a. m., and in the Azusa district about 6 a. m. Considerable wind in all open sections, causing extremely spotted temperature conditions. Firing was light to moderate, scattered in the Azusa and Whittier districts, beginning between 7 p. m. and 8:30 p. m.; and heavy general, beginning between 5 p. m. and 5:30 p. m. in Redlands, Upland, and

Pomona, and 6:30 p. m. in the Corona district. Lowest temperatures by districts: Whittier, 24°; Azusa, 23°; Upland and Pomona, 22°; Corona, 20°; Redlands, 16°.

Imperial and Coachella Valleys.—Clear; little wind; lowest temperature, 17°.

January 24–25, 1937

Sacramento Valley District.—Clear; some wind in spots. Light firing for lemon tree protection only began about 4 a. m. Lowest temperature in district, 21°.

San Joaquin Valley District.—Clear sky except for a few scattered high clouds. Light scattered firing began late in the night. Lowest temperature, 22°.

Santa Paula District.—Intermittent cloudiness during much of the night, varying in different sections. Considerable wind in some sections. Minimum temperatures well above 32° at many points. Light scattered firing 3 to 4 hours before sunrise. Lowest temperature, 26°.

Southern California.—Intermittent broken cloudiness during most of the night, heaviest in the Whittier district. Little wind. Light scattered firing on low ground in the Azusa district about 9 p. m. and in the northern portion of the Whittier district about 1 a. m. Moderate general firing began in Upland about 6:30 p. m., Corona, Redlands, and Pomona about 9 p. m. No firing in the southern portion of the Whittier district or on high ground in the Azusa district. Lowest temperatures by districts: Whittier, 27°; Pomona and Azusa, 25°; Corona and Upland, 24°; Redlands, 23°.

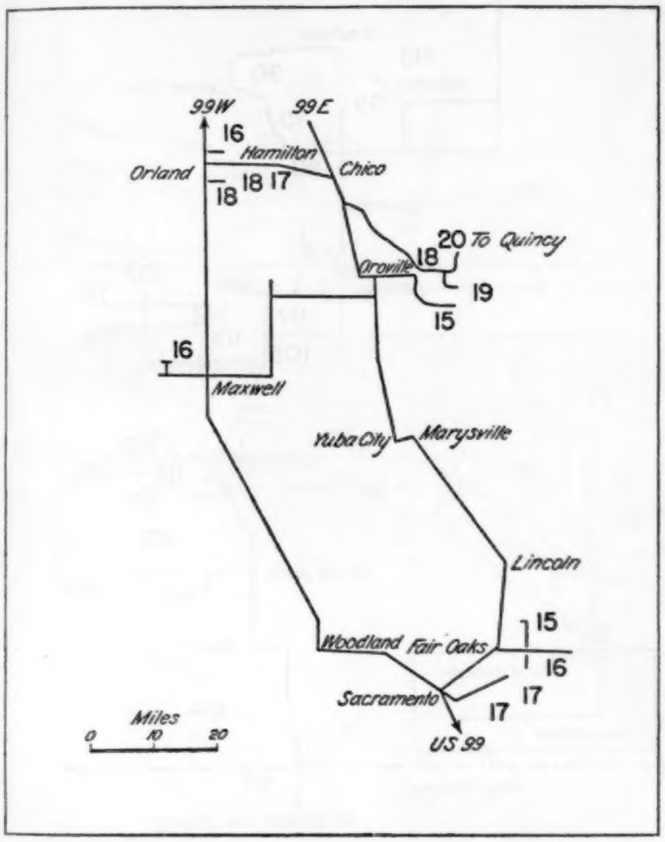

Figure 1.—Lowest temperature recorded in citrus groves during 1936–37 season in Sacramento Valley.

Imperial and Coachella Valleys.—Clear; little wind; lowest temperature, 20°.

January 25–26, 1937

Sacramento Valley District.—Considerable cloudiness in western portion of the district, with lowest temperatures above 32° at many points. Light firing for lemon tree protection. Lowest temperature in district, 23°.

San Joaquin Valley District.—Some scattered cloudiness during the latter part of the night. Light scattered firing began late in the night. Lowest temperature in district, 24°.

Santa Paula District.—Clear; wind in open sections. Lowest temperatures at many points above 32°. Scattered light to heavy firing began about 1 a. m. Lowest temperature, 22°.

Southern California.—Clear; little wind in most sections, although temperatures at a few individual stations did not drop below 32°. No firing in Whittier district. Light scattered firing began in Azusa about 11 p. m. Moderate general firing in Corona district about 9 p. m. Heavy general firing began about 9 p. m. in Upland and Pomona, and 10 p. m. in Redlands. Lowest temperatures by districts: Whittier, 26°; Azusa, 25°; Pomona, 24°; Corona and Upland, 23°; Redlands, 20°.

Imperial and Coachella Valleys.—Clear; little wind. Lowest temperature, 16°.

January 26–27, 1937

By this date a low-pressure area in the Pacific Northwest had spread sufficiently far southward to cause southwest winds over practically all of California. Damagingly low temperatures continued in the Imperial and Coachella Valleys, with the minimum for the district 20°, but lowest temperatures in other districts ranged from 26° to 29°. There was light scattered firing in the Santa Paula, Azusa, Pomona, and Redlands districts, beginning between 10 p. m. and midnight, but heaters were extinguished later in the night in most localities when the sky clouded over. Heaters were not lighted in any other district.

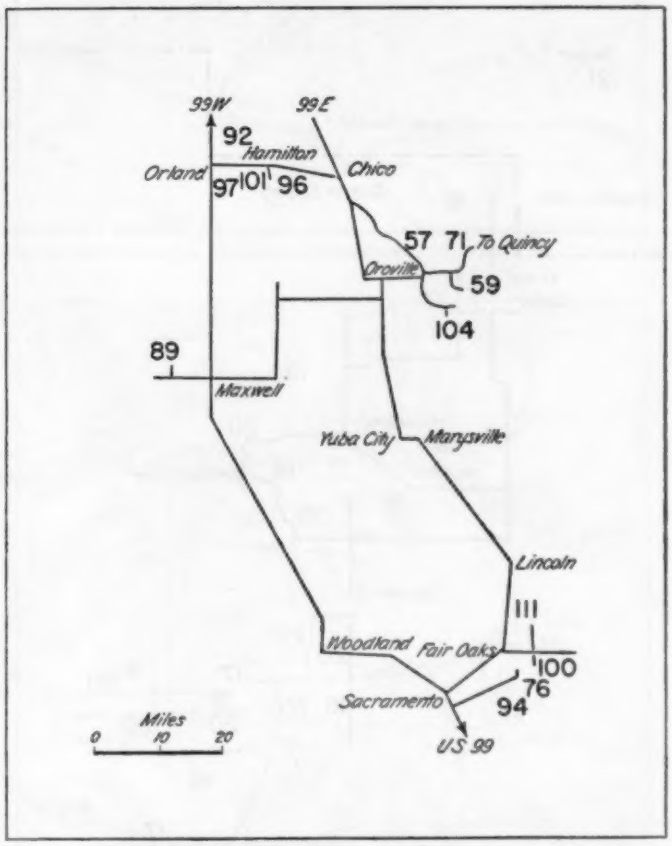

Figure 2.—Total number of hours the temperature was 27° or lower in the citrus groves of Sacramento Valley during the 1936–37 season.

January 27–28, 1937

This night marked the end of the freeze. The only temperature below the danger point was 24° in the Imperial Valley. Lowest temperatures in other districts ranged from 27° to 37°. There was no firing in any district.

COMPARISON BETWEEN 1913, 1922, AND 1937 FREEZES

Temperatures recorded in southern and central California citrus districts in January 1937 were the lowest since January 1913. In the Sacramento Valley lower temperatures were registered during the record breaking freeze of December 1932. While data are available from only a few points, it is possible to make fairly direct comparisons between minimum temperatures recorded during the January freezes of 1913, 1922, and 1937.

TABLE 1.—*Minimum temperature for district (°F.)*

Station	January 1913	January 1922	January 1937
Redlands	18	19	[1] 17
Riverside	21	19	[1] 20
Indio	16	23	13
Calexico	21	23	14
San Bernardino	18	22	17
Fontana	------	24	16
Claremont	19	20	[1] 22
Pomona	18	18	[1] 20
Sierra Madre	28	------	23
Yorba Linda	26	26	24
Tustin	32	23	22
Porterville	18	22	19
Lindsay	13	20	18
Lemon Cove	18	24	18

[1] Minimum temperature readings affected by orchard heating in vicinity.

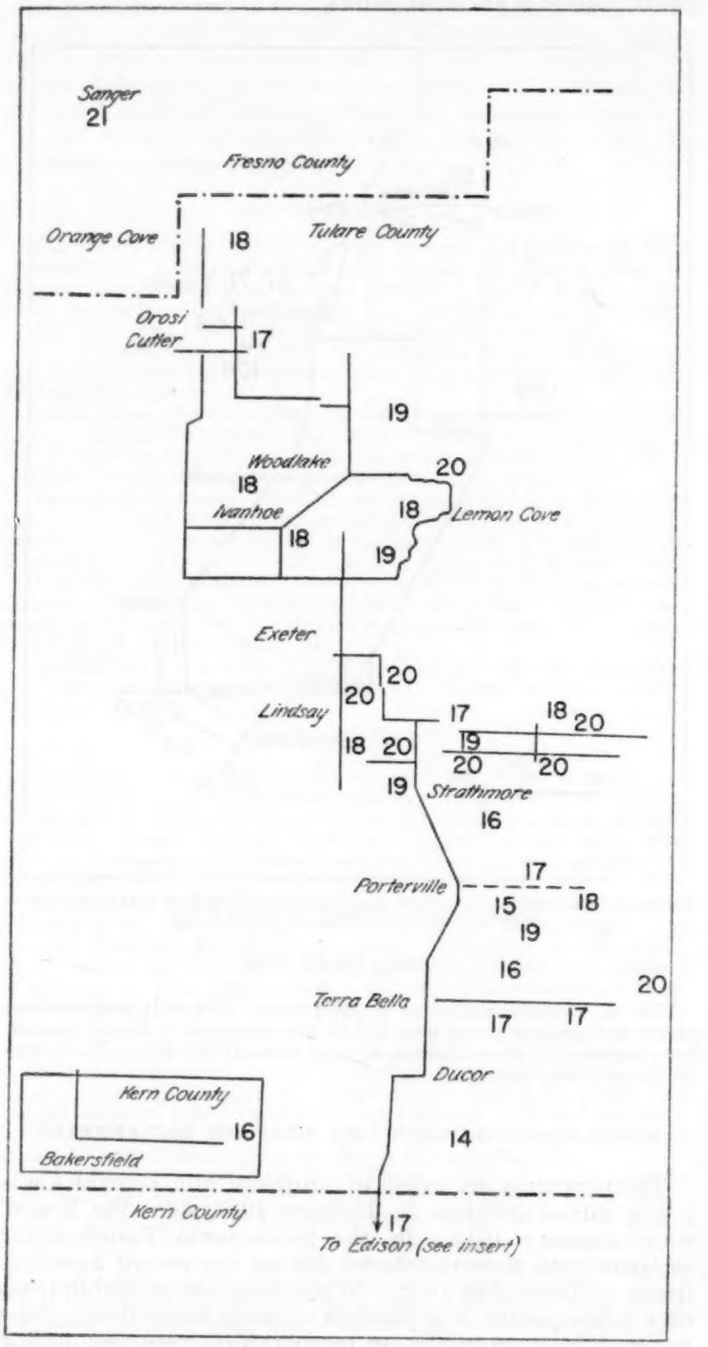

FIGURE 3.—Lowest temperatures recorded in citrus groves during the 1936–37 season in central California.

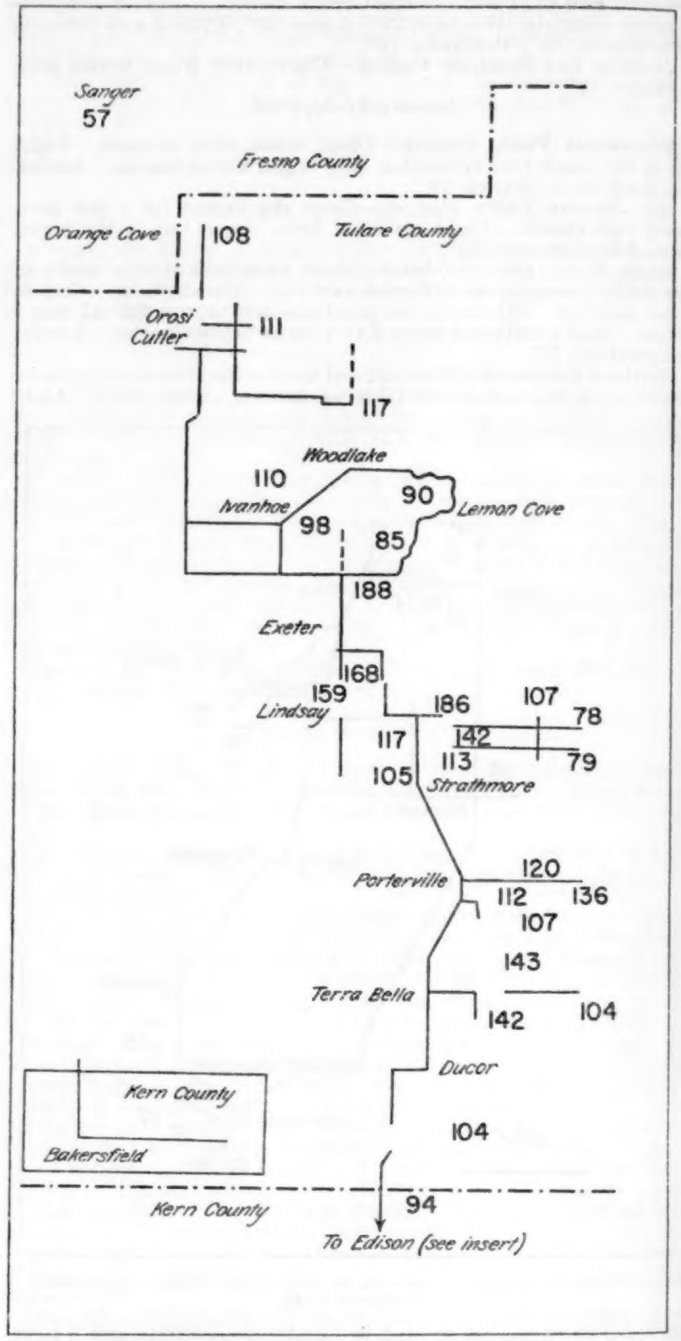

FIGURE 4.—Total number of hours the temperature was 27° or lower in citrus groves during the 1936–37 season in central California.

While some of the temperature data in table 1 are not strictly comparable because of slight changes in the location of thermometers since 1913, they are the best that are available. Temperatures at Redlands, Riverside, Pomona, and Claremont were influenced in 1937 by mass orchard heating in the vicinity of the stations. The amount of this effect on the minimum temperature is very difficult to estimate, but probably was 1° or 2° at Redlands, 4° at Riverside and Claremont, and 5° at Pomona. At all points listed in the table located in districts where there was little or no orchard heating in 1937 minima are lower than those of 1922, in some sections very much lower.

The records indicate that minimum temperatures in San Joaquin Valley citrus districts were about the same

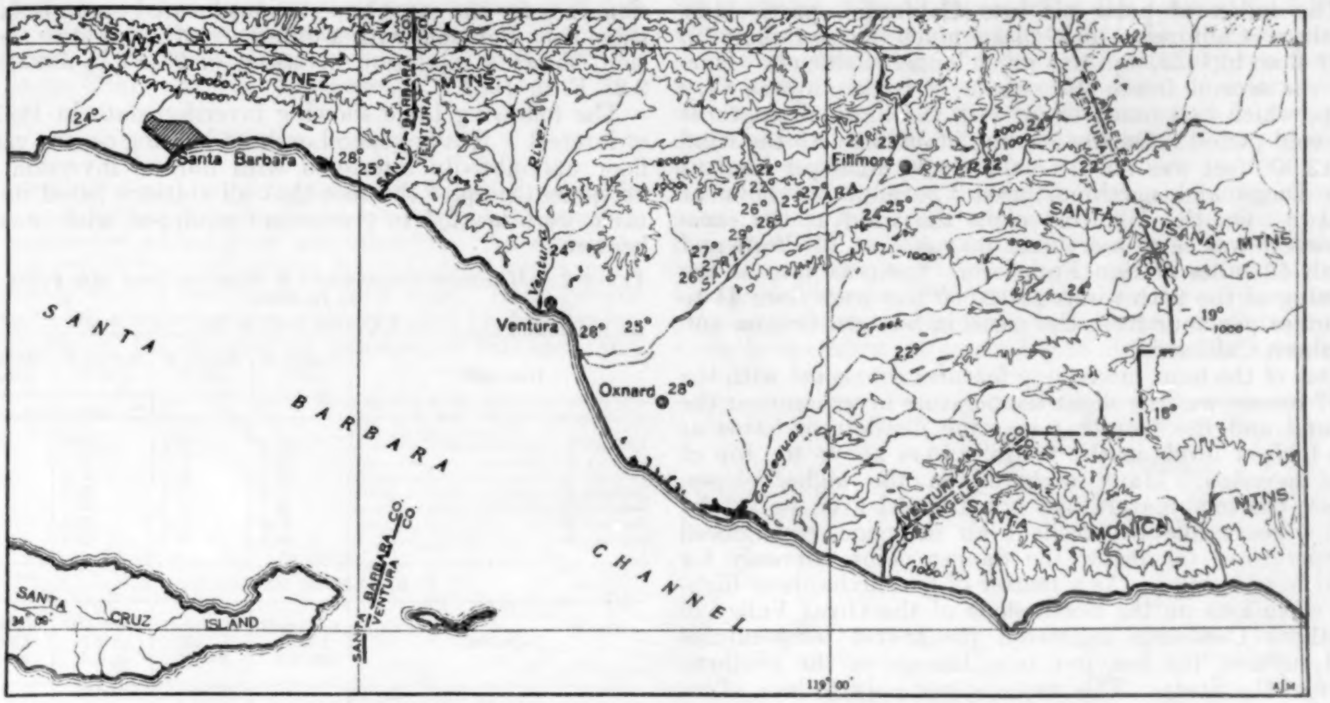

FIGURE 5.—Lowest temperatures recorded in citrus groves during the 1936–37 season in Ventura and Santa Barbara Counties.

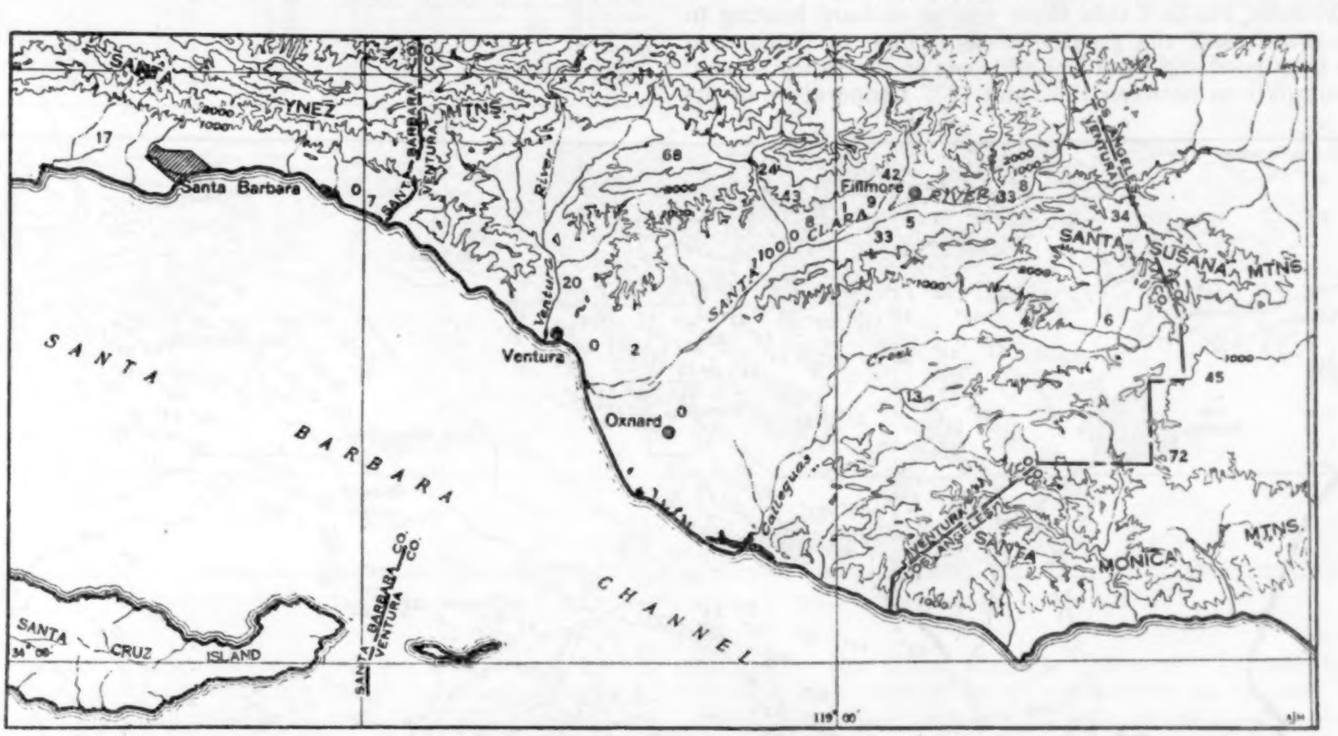

FIGURE 6.—Total number of hours temperature was 27° or lower in citrus groves during the 1936–37 season in Ventura and Santa Barbara Counties.

or slightly lower in 1913 than in 1937. In southern California, however, all the evidence indicates that the temperature fell as low or lower in 1937 than in 1913.

Duration of the 1937 freeze was definitely longer than either the 1913 or 1922 freeze, both in central and southern California. In the San Joaquin Valley the 1913 freeze continued 4 days, January 5 to 8, inclusive. In southern California it continued from 1 to 4 days, depending on locality. The 1922 freeze continued for 6 days in central California, and from 4 to 6 days in southern California. During the two freezes of January 1937 there were 10 days with temperatures below the danger point in central California and 11 days in southern California. Considering both temperature and duration, the 1937 freezes broke all known records in all California citrus districts except those in the Sacramento Valley.

Intensity of the freeze naturally varied considerably in different localities. Figures 1 to 10 show lowest temperatures registered during the winter of 1936–37, together with total number of hours the temperature was 27° or lower during the season, for all citrus districts in which the Weather Bureau Fruit-Frost Service operates.

The influx of polar air into California, particularly southern California, took place much more rapidly in 1937 than in 1922, and was much longer sustained. During the second freeze the stream of frigid air was very deep, which had much to do with the unusual length of the cold period. On the evening of January 19 the wind at 12,000 feet was north-northwest 76 miles per hour at San Diego and north-northeast 75 miles per hour at Seattle. On the following night the wind at the same elevation was north-northeast 66 miles at Medford and north 52 miles at San Francisco. Even as late as the evening of the 24th winds at 12,000 feet were from 44 to 48 miles per hour from the north in western Oregon and northern California.

One of the most interesting features connected with the 1937 freezes was the slight temperature inversion near the ground and the fact that in some districts orchards at the highest levels in the foothills were above the top of the inversion. Many orchards on the higher slopes, where the temperature had not dropped even to 32° for many years due to excellent air drainage, experienced temperatures far below the danger point not only for fruit but for trees. As a matter of fact orchards at highest elevations on the north slope of the Great Valley of southern California registered the lowest temperatures and suffered the heaviest tree damage in the southern part of the State. This was due not only to lack of inversion above the groves, but also to increased wind movement, the fact that there was no orchard heating to windward, and the greater susceptibility to damage of the trees resulting from lack of frosts earlier in the season. A comparison between 1922 and 1937 temperature inversion data for the same two stations located on an isolated ridge near Pomona, with a difference of 225 feet in elevation, shows a minimum inversion of 9° F. in 1922 and 2.2° F. in 1937.

The following table showing inversion data in 1937 is of interest. Heavy general orchard heating on the valley floor undoubtedly interfered with normal inversion development despite the fact that all stations listed in the table were located in groves not equipped with orchard heaters.

Table 2.—*Minimum temperatures at elevations from near valley floor to foothills*

UPLAND DISTRICT

Date (1937)	Station 45 1,025 ft. m. s. l.	Station 18 1,525 ft. m. s. l.	Station 48 1,850 ft. m. s. l.	Station 17 2,150 ft. m. s. l.
January 9	22.3	24.9	23.0	22.0
January 20	23.2	28.0	27.1	24.0
January 21	22.0	24.6	23.0	21.0
January 22	21.5	24.4	24.0	21.9
January 23	22.7	25.8	23.4	22.0
January 24	23.9	27.9	27.0	25.2
January 25	24.0	29.1	32.4	29.0

REDLANDS DISTRICT

Date (1937)	Station 63 1,625 ft. m. s. l.	Station 47 1,710 ft. m. s. l.	Station 39 1,875 ft. m. s. l.	Station 64 2,250 ft. m. s. l.
January 9	22.8	21.1	18.9	18.0
January 20	26.1	25.0	24.2	23.0
January 21	21.5	20.0	17.8	16.0
January 22	21.6	17.2	18.0	16.0
January 23	24.8	17.8	18.0	15.0
January 24	23.8	22.0	24.0	21.0
January 25	26.5	25.4	27.0	25.0

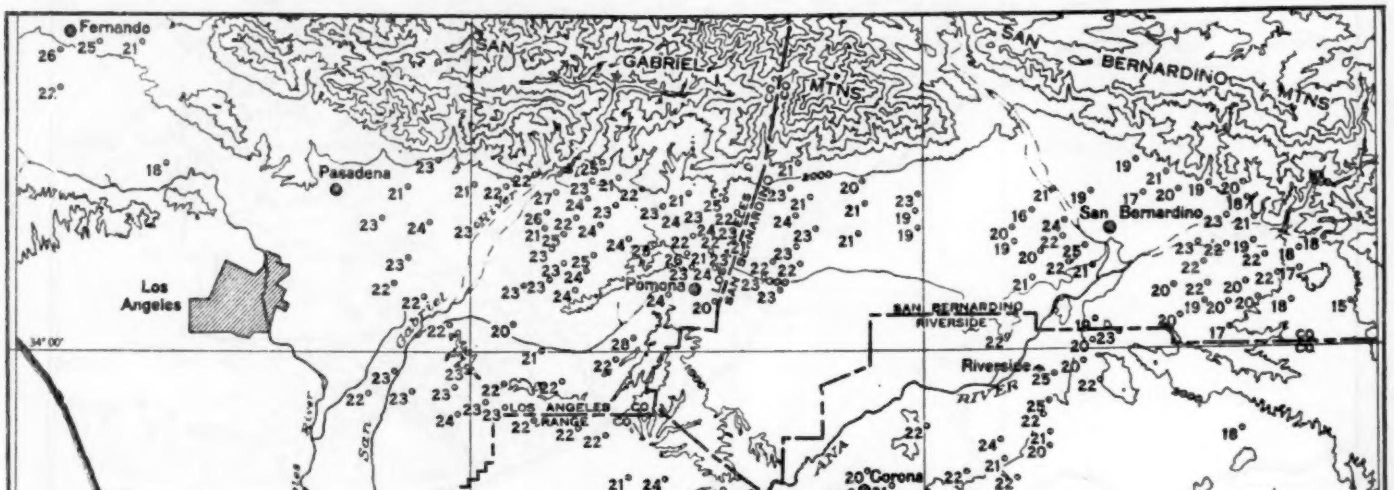

Figure 7.—Lowest temperatures recorded in citrus groves during the 1936-37 season in southern California.

Minimum temperatures for the freeze period at higher elevations in the mountains were: Mt. Wilson, elevation 5,850 feet, 7° F.; Squirrel Inn, elevation 5,700 feet, 0° F.; and Seven Oaks, elevation 5,000 feet, 0° F.

FORECASTS

The value of weather forecasts of any kind depends to a great extent on the timeliness with which they reach the people for whom they are intended. An elaborate telephone frost warning system in use in 1922 broke down completely during the freeze of that year. Each grower reached with a warning immediately called his firing crew, his neighbors, his cooperative association manager, and the Weather Bureau Office, causing a complete tieup of both local and long distance telephone lines. Much of the loss of fruit and trees suffered at that time might have been avoided had all growers been able to obtain the warning promptly.

Since 1930 minimum temperature forecasts have been broadcast nightly during the frost season over a powerful Los Angeles radio station direct from the Weather Bureau Office at Pomona over remote control lines. Continuation of this arrangement by the Columbia Broadcasting Company after its purchase of the station in 1936 was accomplished in the face of great difficulties, due to chain program releases. Without this public spirited cooperation, making it possible to reach every citrus grower in the State within a few minutes after the forecast had been completed, adequate dissemination of the forecasts would have been impossible. In addition to nightly broadcasts at 8 p. m., giving every possible item of information which might assist the growers in their battle to save the crops, a brief statement was made at 1:55 p. m. daily throughout the freeze periods.

Conditions expected during the night, including cloudiness, wind, rate and character of temperature fall, deposit of ice on trees and fruit, temperature inversion, and time necessary to begin firing, together with a forecast for the following night, were given for 10 different fruit growing districts in the night broadcasts. Definite minimum temperature forecasts for 76 different temperature stations in the citrus districts followed. Temperature forecasts also were given to subscribers on request by central telephone operators in some localities, and were thrown on screens or announced over sound equipment in motion picture theaters.

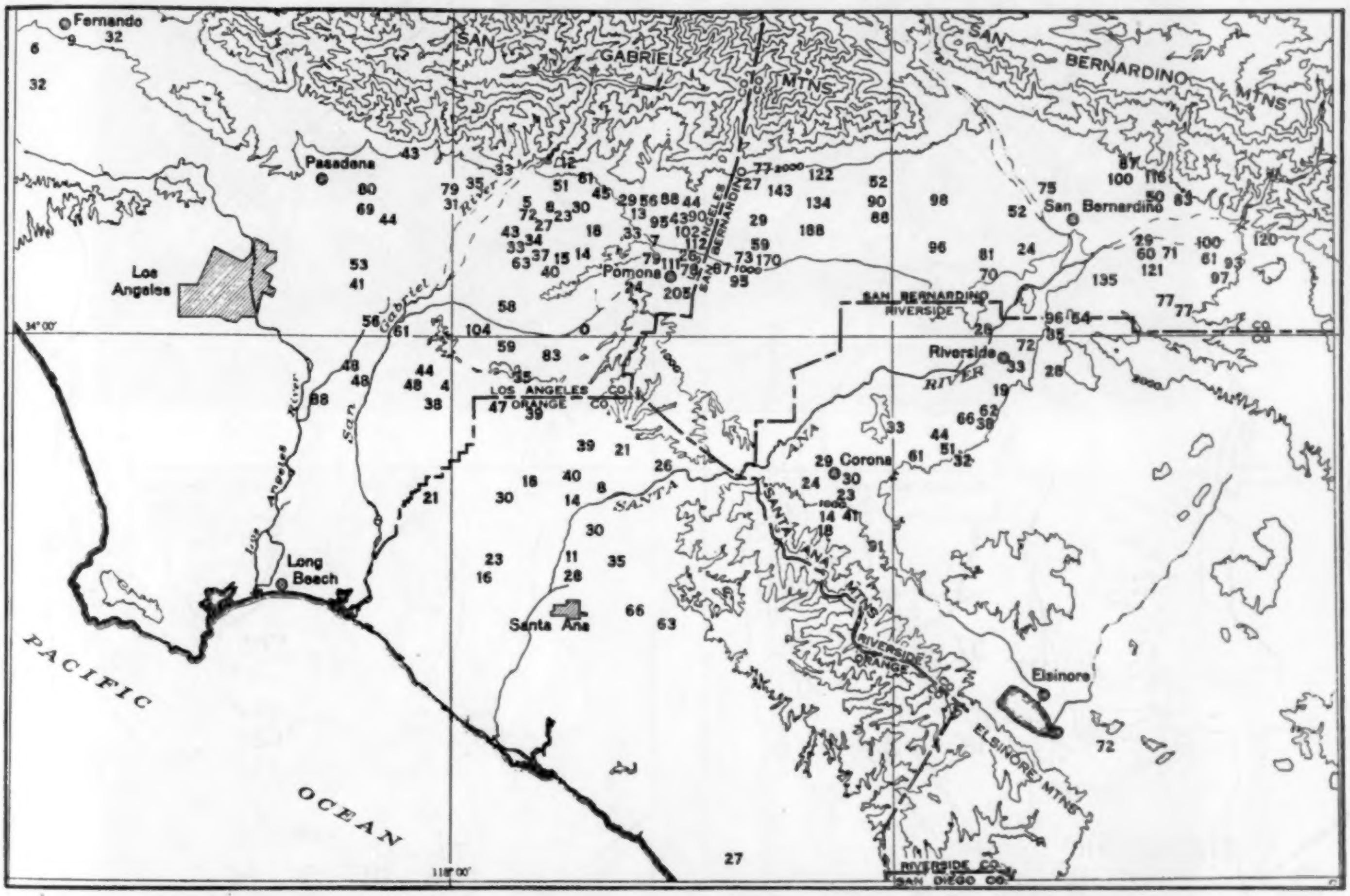

Figure 8.—Total number of hours temperature was 27° or lower in citrus groves during the 1936-37 season in southern California.

Increasing difficulty in obtaining orchard heater fuel and inability to maintain what they considered to be safe temperatures through orchard heating caused many growers to become discouraged during the second freeze and consider abandoning the fight. With this situation in mind the following broadcast to growers in southern California was made at 1:55 p. m. on January 21.

With the eastward passage of the southwestern low-pressure area a great mass of frigid air from interior western Canada has moved

southward and settled over the Plateau Region and the Southwest. Temperatures this morning were below zero over practically all of the interior northwestern quarter of the country, and in northern Nevada the temperature at 5 a. m. was 30° below zero, breaking the all-time record for that section.

Conditions this morning are very similar to those which prevailed during the 1922 freeze, but it is expected that the temperature will fall 2° or 3° lower in the coldest spots than it did in 1922. The lowest temperatures will be recorded in sheltered spots on the low ground, and it is expected that they will be as low as 16° by morning. Temperatures in areas unsheltered from northeast winds will be somewhat higher, but even in windy sections the temperature will drop to 24° or 25°. Firing will begin in some locations by 5:30 p. m. and will continue until at least 10 a. m. tomorrow. Growers

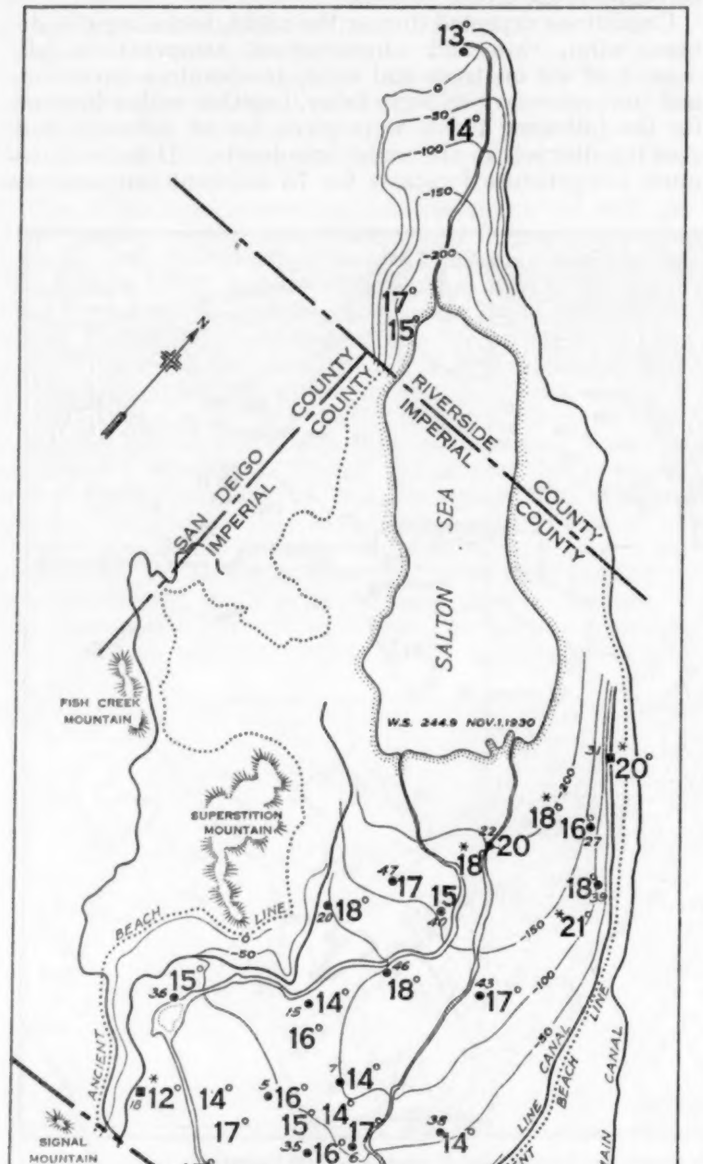

FIGURE 9.—Lowest temperatures recorded in citrus groves and winter truck crop areas in Imperial and Coachella Valleys.

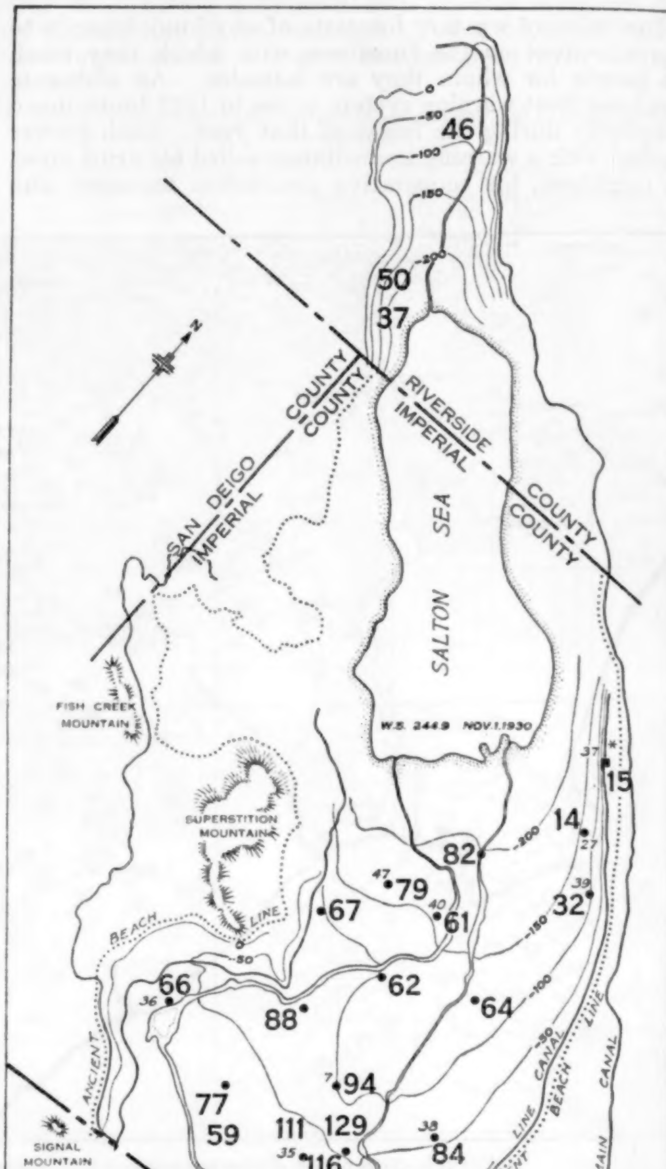

FIGURE 10.—Total number of hours temperature was 27° or lower in citrus groves and winter truck crop areas during the 1936–37 season in Imperial and Coachella Valleys.

FIGURE 11.—Contrast between protected and unprotected mature lemon trees following 1937 freeze. Even tender buds and blossoms in protected groves were undamaged.

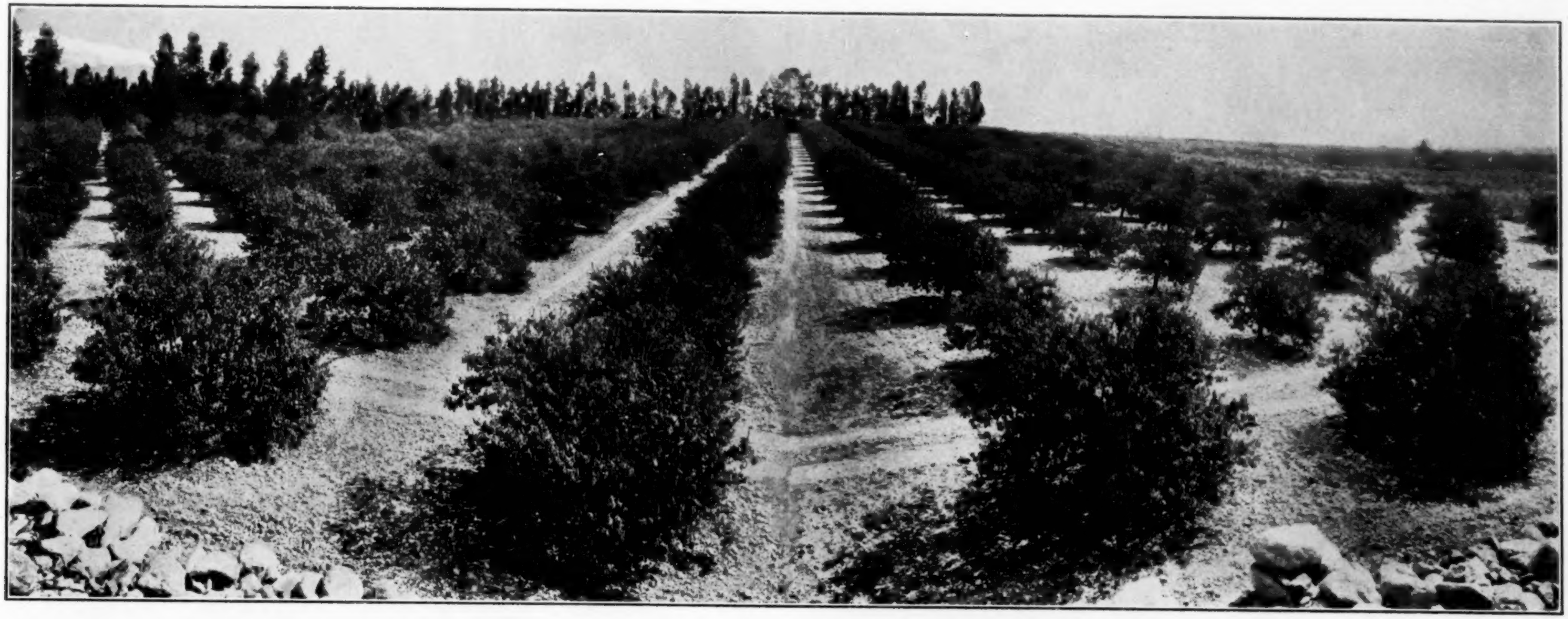

FIGURE 12.—View of mature lemon grove without protection; every tree killed to the ground.

FIGURE 13.—25-year-old lemon tree with bark split by low temperatures; no protection.

FIGURE 14.—Mature grapefruit trees, unprotected, showing complete loss of crop and defoliation.

who have tank wagons should have them filled and ready for action so that heaters can be refilled during the night where necessary.

Experience during the 1913 and 1922 freezes was that considerable fruit was salvaged in groves in which the heaters were kept burning all night, even when the temperature could not be maintained above the danger point. However, in cases where the grower plans to make no further effort to save the crop, the probability of severe tree damage should be kept in mind.

Mature lemon tree foliage damage usually starts at long continued temperatures of 26°, and 24° for a long period will cause about 50 percent defoliation. Twenty-three degrees will cause complete defoliation and bark will be split by long continued temperatures of 19°.

Severe foliage damage to mature orange trees is likely to follow long continued temperatures of 23°, and almost complete defoliation and some bark splitting on branches has resulted from temperatures of 18°.

Young trees are, of course, much more susceptible to damage, and the temperature should not be allowed to fall below 26° in young groves if all damage is to be prevented.

After the sun is high enough in the morning, heaters can be extinguished even though the thermometer still reads slightly below the danger point.

Lowest temperatures tomorrow night will be only slightly higher than tonight, and present indications are that this freeze will have to wear itself out slowly, with probably some improvement each day, but with firing for three more nights.

Advice to continue the battle and keep the heaters burning as long as it was humanly possible to do so was repeated in the evening broadcast. Its soundness was demonstrated in hundreds of cases of little or no damage to fruit or trees in groves heated consistently despite temperatures which appeared to be considerably below the danger point.

The load on the telephone lines was extremely heavy during the freeze despite the dissemination of the forecasts by radio. Requests for elimination of social telephone calls so that lines could be kept clear for frost protection business were broadcast by telephone company officials. Telephone exchanges in citrus districts carried loads from 80 percent to 90 percent above normal throughout the freeze periods. On January 21 all records for traffic volume were broken at Pomona, with 94,000 calls, and at Covina with 49,900 calls. The manager of the Associated Telephone Company reports:

A noticeable falling off of telephone traffic occurs just previous to the evening broadcast. On cold nights this is immediately followed by a rush of calls as ranchers call for assistance, business men call for clerks to cover merchandise, and housewives call neighbors and friends to prepare to protect furnishings, etc. Socials, business meetings, even church services, are quite generally stopped to listen to the broadcast during critical periods.

At Pomona three telephones were kept busy constantly throughout the period of the two freezes, and telephones at nine other fruit-frost district headquarters in the field were similarly busy. The extreme nervous tension under which growers and their families were laboring was reflected in their voices. In many cases women burst into tears after obtaining the forecast by telephone.

The Board of Directors of the California Fruit Growers Exchange in a resolution commending the forecasting work stated in part:

The interpretation of weather data * * * resulted, as usual, in forecasts so accurate that not only could crops be saved through heating, but by proper timing considerable fuel oil could be saved for the next emergency, which was vital during such long periods of low temperature, both from the standpoint of costs and conservation of fuel supply.

The Mutual Orange Distributors, another cooperative citrus marketing agency, published the following in its grower magazine:

It is beyond doubt that the work of the frost protection and notification program of the United States Weather Bureau at Pomona was highly efficient. Had all of the factors in frost protection been as well organized as this, the loss undoubtedly would have been much less. Regular evening broadcasts over KNX were supplemented by bulletins to sales organizations and other central parties at frequent intervals throughout the day. The general accuracy of all forecasts was remarkable.

The following is quoted from a letter from the Los Angeles Chamber of Commerce:

Value of the broadcasts was doubly manifested because of the extreme irregularity of the temperature. Certain localities that had previously been thought to be exempt from frost damage experienced subnormal temperatures, ample warning of which was given, thereby making it possible to be prepared.

From the Whittier State School:

It was through the warning of the approaching frigid wave that this institution purchased its first heating units for the citrus grove, and, of course, we were successful in saving not only practically all of the fruit, but we eliminated tree damage as well.

DAMAGE CAUSED BY FREEZES

The amount of damage to citrus crops by low temperature is very difficult to estimate. Any loss estimate in percentage of the total crop must be based on an estimate of the size of the crop on the trees before the damge took place. At the end of the season the California Fruit Growers Exchange estimated the amount of fruit rendered unfit for shipment through freezing injury at 40 percent of the crop on the trees when the freeze began. Approximately one-third of the State Navel orange crop had been picked before the first freeze began. Ninety percent of the Navel crop in the San Joaquin Valley had been harvested. As nearly as can be estimated, citrus fruit rendered unfit for shipment by the freezes represented approximately 30 percent of the total crop on the trees at the beginning of the season. This compares with 62 percent damage by the 1913 freeze and 50 percent by the 1922 freeze.

The 1937 loss of citrus fruit through freezing damage was 16,000,000 boxes, or 35,000 carloads. In addition to the fruit rendered valueless except for byproducts, it is estimated that approximately 10,000 carloads of fruit was damaged slightly, necessitating its marketing in lower grades which sold at a lower price than undamaged fruit.

It is even more difficult to estimate the value of the fruit damaged by low temperatures, since the price per box was considerably higher than it would have been if the entire crop on the trees before the freeze had been shipped. Actually the 1937 crop brought to California approximately $9,000,000 less than the crop of the previous season. The 1937 crop, 30 percent less in volume than the 1936 crop, brought only 8 percent less return. In other words, the California crop alone cost consumers nearly $25,000,000 more because of the freeze, based on the per box consumer cost of the 1936 crop. Prices for the Florida crop were increased proportionately, making the total cost of the freeze to the consumer probably in excess of $50,000,000. If there had been no frost protection in California the 1937 crop would have been reduced in size much more drastically, and prices to the consumer would have been much higher.

If the $9,000,000 loss to the California growers due to the freeze had been evenly distributed, the results would not have been very serious. As a matter of fact, however, many growers without frost protection equipment, as well as a few who spent large amounts for frost protection but who were unable to secure sufficient fuel to carry through the entire freeze, lost their entire crops, while others, whose crops were undamaged, actually profited by the freeze. Trees in many groves were severely damaged, and in a few cases entire orchards were frozen to the ground.

Costs of replacing valuable orchards which were destroyed and rehabilitating orchards frozen back almost to the tree trunks also are very difficult to estimate.

Damage in general was astonishingly slight, considering the temperatures and low temperature durations. Damage to fruit was 20 percent less than in 1922 and tree damage also was much smaller, despite the fact that the 1922 freeze was much less severe in all respects. Reasons for the smaller amount of damage in 1937 than in 1922 are obvious. The tremendous increase in acreage equipped with orchard heaters since 1922 and the much greater efficiency with which frost protection operations were handled were undoubtedly the greatest factors. Effects of "mass heating" also were very important. Unprotected orchards located to leeward of heavily fired groves received much benefit from drifting heated gases, and all unprotected groves located in areas in which more than 70 percent of the acreage was equipped with heaters received a large amount of protection. In many cases such groves showed no damage to trees or fruit following the freeze. It is believed the heavy orchard heater smoke, which covered most of southern California throughout the duration of both freezes, materially reduced the amount of damage through shading trees and fruit from the sun during the day. This conclusion is based entirely on observation, but there has been much evidence during the past 25 years to support it.

Weather preceding the 1922 freeze was warm both day and night, with frequent warm showers, making both trees and fruit particularly susceptible to low-temperature damage. Following the 1922 freeze the sky was clear, with bright sunshine, and day temperatures rose quickly to 75°. Damaged fruit began to drop from the trees within two days after the freeze had ended, and damaged foliage quickly curled and dried.

During December 1936, on the other hand, frequent light to moderate frosts hardened trees and fruit. Day temperatures were unusually low, remaining below 60° at Pomona from December 23 to the end of January. There was much cloudy weather, with frequent rains, which slowed tree growth. Cold rains immediately following the freezes appeared particularly to benefit trees whose foliage had curled badly and gave every indication of losing all their leaves. In contrast to the extremely unfavorable weather before and after the 1922 freeze, the weather which preceded and followed the two freezes of January 1937 could hardly have been more favorable.

Damage caused by the 1937 freeze was of course not confined to oranges, lemons, and grapefruit. Practically all the lime trees in the State were completely defoliated and many were killed. A large percentage of the avocado acreage suffered heavy foliage damage, and the crop was reduced by 33 percent. The stems of mature avocados were frozen in many cases with little or no damage to the fruit, but weakening of the stems caused the fruit to fall from the trees, resulting in a flood of fruit which had to be marketed immediately after the freezes had passed.

The cut flower industry of southern California, which normally ships from 6 to 13 carloads of flowers per day, suffered a loss of $200,000 due to the cold. Loss to winter truck crops of the State was estimated at approximately $2,000,000. California normally ships about 500 carloads of vegetables per day during the winter months. Following the freezes not only were shipments cut off, but it became necessary to import vegetables into the State from Mexico and Florida to supply local demand. Prices of fresh vegetables increased from 50 to 100 percent, and prices of canned vegetables also advanced sharply. All subtropical nursery stock suffered severe damage except where given adequate protection against low temperatures.

The pouring of concrete in the open was discontinued during the coldest periods, and many calls for forecasts were received from contractors, both in person and by telephone.

GENERAL ASPECTS OF THE FREEZE

The spectacle of thousands of orchardists fighting to prevent the loss of practically everything they owned, aided by every agency both public and private that could possibly be of assistance, baffles description. The most intensive fight was waged to secure fuel to keep the orchard heaters burning.

Railroad companies had a very vital interest, almost as deep as the growers themselves, in preventing damage to trees and crops, since much of their annual revenue comes from the movement of the fruit. On the strength of the first warning of impending cold, before the arrival of the freeze, one railroad company began to bring tank cars of every description from all parts of its line into southern California. More than a hundred cars which had been used to transport cocoanut oil were rushed south from the the San Francisco Bay region. Cars which had been used to carry gasoline, molasses, alcohol, road oil, and even fish oil were concentrated in southern California for the movement of orchard heater oil. There was no time for cleaning the cars, and many a gallon of molasses was burned in the heaters during the freeze. Delivery of cars to the great number of destinations in the citrus districts involved large scale switching operations, necessitating a large number of trains. At times as many as a dozen oil trains operated simultaneously along a 50-mile railway line. In order to simplify operations and minimize confusion, all tank cars were pooled by the railroads, regardless of ownership.

All railroad crews in southern and central California were pressed into service, and as the fuel shortage became more acute additional crews were brought in from as far east as Texas and as far north as San Francisco. Train crews were worked the legal limit of 16 hours, given 8 hours rest at whatever point they happened to be located, and put back to work. Movement of every other type of freight except the most perishable was subordinated to movement of oil. For several days at a time oil was moved almost exclusively. Near the end of the second freeze the railroads notified the citrus growers that their own supplies of oil for locomotive fuel were practically exhausted and the cars would have to be diverted to their own use if rail operations were to continue. Orchard heater oil transported by rail during the freeze period totaled 4,435 12,000-gallon carloads. At one time unfilled orders for more than 1,500 carloads of oil were on file at the cooperative purchasing agency of the California Fruit Growers Exchange alone.

Motor tank trucks were similarly mobilized before the freeze, many being brought to southern California from points 500 miles distant. Trucks were pressed into service which had been used to haul such commodities as honey, cider, and even oil-well mud. Junk yards were combed for any tank trucks which could move under their own power, and permission was granted by the State to operate them without license plates. Trucks were lined up for more than a mile at loading points. Ice companies, milk distributors, and automobile truck dealers all cooperated in moving oil to groves. Fuel transportation continued with feverish speed both day and night. County road crews were kept busy sanding roads which had become

slippery with spilled oil. Caravans of oil trucks were convoyed at full speed by highway traffic officers from oil refineries to citrus districts, where they scattered to grope their way through the heavy smoke to their various orchard destinations. Disputes over oil deliveries, and ownership of oil in community tanks were numerous and resulted in many court suits later.

Diversion of trucks to orchard-heater fuel service interfered seriously with fuel-oil delivery for heating buildings, and guests shivered in many a large hotel and apartment building. Development of the heaviest demand for natural gas ever experienced made it necessary to curtail supplies for industrial use and many factories were forced to close temporarily. Laundries were particularly hard hit, due to the tremendous increase in volume of business caused by the smoke and soot, and the difficulty in keeping fabrics clean after laundering, as well as the shortage of gas for plant operation.

Discarded automobile tires were brought in from increasingly-distant points for orchard heater fuel, and the price rose steadily from 10 dollars per ton at the beginning of the freeze to 50 dollars per ton near the end. In some cases growers, unable to secure orchard heater oil, bought up all the kerosene obtainable in their vicinity and burned it in their heaters. One grower, unable to maintain a satisfactory temperature in his grove with his heaters, burned additional oil poured into holes scooped in the frozen ground.

The orchard heater fuel situation was desperate in many localities on the night of January 23. In the Redlands district oil was available for only one-half the heaters during the day and storage tanks were dry. The arrival of a trainload of oil at 9 p. m. was too late for a few groves but averted disaster in most cases.

Irrigation water, poured into orchards during the second freeze in the hope that it would lessen crop damage, froze rapidly, and was still solidly frozen 4 days later. Fish ponds and other still water remained solidly frozen throughout both freeze periods, and the Santa Ana River, reduced to creek size by diversion for irrigation, was completely frozen on January 24. Icy streets and highways, heretofore unknown in southern California, created serious traffic hazards. Falls on icy sidewalks caused many injuries. In Los Angeles a can of milk fell from a truck and the milk froze on the street car tracks, causing a wreck which injured 14 passengers. Water pipes froze in many southern California cities, and in one citrus belt town two trucks were kept busy turning off water at residence meters to prevent damage. In the Imperial Valley stock went without water because of heavy ice forming on watering troughs, and repair shops reported more than 100 tractor and 200 automobile radiators damaged by freezing. At Oroville, in the Sacramento Valley, ice thick enough for skating formed on the Feather River and remained for several days.

The fight to supply fuel to the orchards and to keep heaters burning to save the crops took place under a thick black canopy of orchard-heater smoke, so heavy that it started operation of automatic fog horns at Los Angeles harbor and necessitated the burning of street lights in some citrus belt cities until after noon. In some localities heaters were lighted at 4:30 p. m. and were not extinguished until 12:30 p. m. on the following day.

Fruit growers, including retired professors, physicians and business men, unshaven and incredibly dirty, did not leave their orchards in some cases for 3 days and nights, having their meals brought to them and eating while they worked. Considering the age and state of health of many of the growers, there were surprisingly few deaths from over-exertion and exposure. Outstanding was the loyalty of the men hired to handle the firing and filling of the heaters. The battle to save the crop seemed to imbue them with the same spirit they might have had if they were defending their own homes against an invading army. In some cases firing crews recruited at the beginning of the freeze, personally unknown to the grower, worked doggedly day and night without supervision when the grower became suddenly ill. Hired men often worked 45 consecutive hours without sleep. A few were removed to hospitals when they collapsed due to physical exhaustion.

It was impossible to fill the heaters without spilling oil, and many laborers worked in oil saturated clothing. Oil covered limbs were rubbed raw in the process of carrying buckets of oil to fill heaters. Shivering men stopped a moment to warm themselves at a burning heater and were burned to death or suffered serious injury when their oil-soaked clothing ignited. Explosion of heaters during refilling operations was responsible for other serious injuries. Strangely enough, filling of heaters while still burning proved to be a safe operation. Explosions occurred in filling heaters which supposedly had been extinguished, but which contained smoldering soot which ignited gases. Traffic accidents were frequent due to the heavy smoke.

Many fore-sighted growers avoided accidents to orchard workers by requiring every employee to change clothing after filling heaters, and insisting that no heaters be filled until they had been lighted. The manager of one large orchard purchased 200 pairs of overalls for his men at the beginning of the freeze, all that could be obtained in a citrus belt city. In one 48-hour period more than 200 gallons of coffee were served to the men on this one ranch.

Schools were closed generally in citrus belt cities during the freezes due to the heavy smoke and the difficulty in keeping buildings warm, and also because a large proportion of the students were needed at home to assist in the battle to save the groves. Many stores were closed "for the duration of the African fog." In other stores merchandise which might be damaged by smoke was kept under heavy canvas covers and shown only on request. Housewives covered their furniture, removed drapes and curtains, and in some cases sealed doors and windows with tape.

The strain on everyone connected with the citrus industry, from the growers to the heads of marketing organizations, was terrific throughout the progress of the two freezes. The cold and the all-pervading smoke made the life of the ordinary citizen unpleasant, but it was not until the freeze had passed that a spirit of sympathy and cooperation changed in a few localities to criticism and complaint.

As usual in such crises, a few people with no practical knowledge of meteorology or orchard heating hastened to give their views to the newspapers, adding to the confusion and increasing the difficulties of the harassed growers. One newspaper article ascribed the low temperatures to orchard heater smoke and stated there would have been no freeze without smoke. In districts where the smoke was heaviest it unquestionably interfered with the normal morning rise in temperature, but a comparison of temperature records from the smokiest areas with those obtained in districts where there was no orchard heating and no smoke at any time proves definitely that the effect on the maximum temperature of the day was almost negligible. The absurdity of the argument is further demonstrated by the fact that the lowest temperatures in any of the citrus districts occurred in sections where

there was no smoke; in fact, the records show that minimum temperatures in unheated groves in the smokiest areas were much higher than they would have been if there had been no orchard heating. The great quantities of frigid air pouring into southern California throughout the freeze periods, and the fact that the morning rise in temperature is slower and begins later when the ground surface is frozen were entirely ignored. Minimum temperatures in the Imperial Valley, where there was no heating and no smoke, normally are the same as or higher than those in the Pomona district, where more than 80 percent of the groves are equipped with heaters, during moderately cold periods with little heating at Pomona. The lowest temperature registered in the Pomona district during the freeze was 20.5° F., at a station farthest from any orchard heating operations, while the lowest temperature in the Imperial Valley was 12° F. Generally speaking, the normally coldest areas were warmest during the freeze, due to the greater concentration of heating equipment.

Another published article stated, "If the temperature does not increase rapidly with altitude and does not reach 32°, heating is futile." If this statement were true, orchard heating would have been futile throughout most of the citrus districts of the State during the coldest nights of the freeze. It is true that the protection of lemons in the Sacramento Valley proved impractical with standard orchard heating equipment during the second freeze when the temperature fell to 15° F. accompanied by a strong wind, but more than half the crop was carried through the first freeze without damage, with outside temperature of 22.5° F. accompanied by a strong wind, and 15. 5° F. without wind. In Tulare County there was loss of lemons and some lemon tree damage in isolated groves equipped with heaters, when the temperature dropped to 14° F. In all cases, however, in which standard heating equipment was properly used the contrast between heated and unheated groves was very marked.

In southern California heating was uniformly effective in groves with standard equipment efficiently handled, although there was some damage in groves with too small a number of heaters to the acre. Temperatures over large areas were held hour after hour at 28°F. with outside temperatures of 19° F. In normally cold districts with a high percentage of the total acreage equipped with heaters, there was little or no damage in groves not equipped with heaters. Lowest temperatures were registered in nearly all cases at stations located farthest from heated sections.

Growers have been urged for many years to "stagger" their orchard heaters in the groves, i. e., to place heaters in every row rather than to concentrate them in alternate rows. Soundness of this advice was amply demonstrated during the 1937 freeze, as it had been in previous freeze years, by the damaged fruit in the "dark" rows. There is no questioning the fact that radiation of heat directly from the heaters to the trees and fruit plays an extremely important part in orchard heater protection, especially during nights with wind and little or no temperature inversion near the ground. Since this influence does not appear in sheltered thermometer readings, the grower is likely to underestimate the effectiveness of his orchard heating operations under freeze conditions.

The amount of orchard heater oil consumed during the freezes has been estimated all the way from 82,000,000 gallons, costing $4,000,000 in the heaters, to 100,000,000 gallons, costing $5,000,000. Costs of operating the heaters varied so greatly that estimates are of little value. Estimates of $10,000,000 for fuel and labor have been generally accepted as approximately correct.

The strike which tied up many ships on the Pacific Ocean handicapped forecasting during the freezes, but resulted in an accumulation of diesel oil due to lack of demand for ship fuel, without which orchard heater fuel would have been completely exhausted before the end of the second freeze.

Experience gained during the freezes has resulted in the installation of many new oil-storage tanks in the orchard districts, and the enlargement of loading racks to handle the filling of a larger number of trucks simultaneously. The type and amount of orchard-heating equipment needed to render adequate protection to crops under extreme conditions has been indicated definitely. The fact that trees and fruit can be protected against extremely low temperatures, with little or no temperature inversion near the ground has again been demonstrated.

After the excitement of fighting the freezes had passed and the orchards and the major portion of the crop had been saved, a great hue and cry arose over the smoke nuisance. Several citrus belt counties passed ordinances limiting the output of smoke per heater in a given period of time. Inventors brought forth dozens of new heater designs, practically all of them without practical value. As a matter of fact, practical men have been working constantly during the past 20 years to improve the combustion of orchard heaters, and radical improvement appears very unlikely considering the rigid limitations of cost which the grower is able to bear. Equipment now in use can be made to consume a good grade of diesel oil with very little smoke per heater, but even if the smoke output of every heater were cut to the minimum, the simultaneous burning of the 4,000,000 units in use would still create an objectionable amount. Burning of heaters with a minimum of smoke requires use of clean oil and thorough cleaning of burners at frequent intervals. Growers seldom take time to clean equipment even in ordinary winters, and under freeze conditions such as those of 1937 cleaning is practically out of the question. Oil quality also deteriorates under such emergencies. If the general public insists on smokeless skies when the next freeze occurs, it undoubtedly will have to be at the cost of a tremendous loss to the citrus industry, and indirectly to the public, both in California and throughout the Nation.

TROPICAL DISTURBANCES OF OCTOBER 1938

By J. H. Gallenne

[Marine Division, Weather Bureau, Washington, November 1938]

Three tropical disturbances were charted during October in the North Atlantic and the Gulf of Mexico.[1] The first appears to have originated over northern British Honduras on the 10th and, after pursuing an unusual course, moved inland on the 17th a short distance to the southwest of Galveston, Tex. The second disturbance was located a short distance to the northeast of Bermuda on the 17th. It moved southwestward toward the coast of Florida on the 18th and 19th, then recurved to the northeast on the 20th. The third disturbance was first observed in the west-central portion of the Gulf of Mexico on the 23d. It traveled in a northeasterly direction, moved over northern Florida into the Atlantic Ocean near the Georgia coast, followed the Atlantic seaboard and merged with a LOW trough over New England on the evening of October 24.

Disturbance of October 10 to 17.—The first evidence of unsettled conditions was noted on the evening of October 10, at which time a cyclonic circulation was centered a short distance to the southwest of Tela, Honduras, with a barometer reading of 29.69 inches. For the next 48 hours, while this depression pursued a north-northwest course, ships in the central and east Gulf regions experienced only moderate east and north winds. At 7 p. m.[2] of the 12th, the center was located near 25° N. and 90° W. The disturbance recurved to the east-northeast during the evening of October 12. The S. S. *El Estero* at 11 a. m. of October 13, reported a fresh gale from the northeast accompanied by heavy rain, while near latitude 26° N., and longitude 87° W., barometer 29.71 inches. At 1 p. m. of the same day the S. S. *El Isleo* giving her position as 26°05′ N. and 87°36′ W., reported northeast wind, force 9, the highest thus far reported in connection with this disturbance.

At 6 p. m. of the 14th, the S. S. *Wallace E. Pratt* reported a "calm center" at 25°42′ N. and 84°42′ W., pressure 29.41 inches, the lowest barometer reading of record in connection with this disturbance. The depression then moved in a northerly direction until the morning of the 15th, when it again recurved, this time toward the west-northwest with an increased progressive movement, causing generally disturbed conditions over the northern Gulf. The center passed inland a short distance to the southwest of Galveston, Tex., at about 7:45 a. m. of October 17.

Extracts from a report by the official in charge at Galveston, Tex., follow:

> The course of the storm center and time of crossing the coast lines of Galveston Island and the mainland can be quite definitely established. Wind at the Galveston station and over the western portion of the city veered from northerly to southerly. At the Galveston Municipal Airport, at the San Luis Coast Guard Station, and at Freeport, the wind backed from northeasterly to westerly. Mr. W. D. Stearns, storm warning displayman at Seabrook, Tex., on his way to Galveston at the time, reported strong and increasing northeast winds south of Dickinson, Tex. He also noted the counterclockwise movement of lower clouds and, when nearing Virginia Point at the mainland end of the causeway at about 8:10 a. m., he encountered a distinct lull for a few minutes with the wind veering sharply to the south and increasing again. At the Fort Crockett Airport, about 3¾ miles southwest of the Weather Bureau the wind velocity record from a single register shows a maximum velocity of 36 miles at 7:11 a. m. and an extreme velocity at the same time of 42 miles, decreasing to 11 miles at 7:44 a. m. and increasing to 26 miles at 8:04 a. m. No automatic record of wind direction is made at Fort Crockett. From the above it is believed that the center of this disturbance, probably not over a few hundred yards in diameter, crossed the coast of Galveston Island at or very near Fort Crockett Airport at about 7:45 a. m., E. S. T., on the 17th and moved toward the mainland near the causeway in a west-northwesterly direction reaching the mainland about 8 a. m., E. S. T. * * * The lowest sea level reading at the Weather Bureau was 29.68 inches about 7:20 a. m. The reading at Fort Crockett at approximately the same time, as shown by the barograph trace, was 29.71 inches. The barograph at Fort Crockett is set to run with a high grade mercurial barometer in that office.

Advisories, including warnings for small craft, were issued from the forecast center at New Orleans on October 12 and at frequent intervals thereafter until the disturbance moved inland on the 17th.

Disturbance of October 17 to 20.—A rather weak cyclonic circulation, possibly not of tropical nature, was charted a short distance to the northeast of Bermuda on the morning of October 17. It moved in a general southwesterly direction toward the Bahama Islands for the succeeding 48 hours. During the 19th it crossed the northern part of Great Abaco Island and over the northeast portion of the Grand Bahama Island. From that point it moved northwestward and was located near 28° N. and 79° W., at 7 a. m. of October 20. The disturbance then recurved to the north and northeast and merged with an extratropical low-pressure trough along the Atlantic coast.

Disturbance of October 23–24.—A very shallow LOW developed near 24° N. and 93° W. on the morning of October 23. This depression moved northeastward and at 7 p. m. of the same day was centered about 225 miles south of Pensacola, Fla. At the same time, the S. S. *Bertha Brovig* near 26° N. and 89½° W., reported a fresh north-northwest gale, barometer 29.77 inches. Several other vessels in the vicinity reported encountering strong to high winds. During the early morning of the 24th, the disturbance crossed the Florida coast line north of Tampa with a maximum wind velocity of 38 miles an hour at Tampa at 6:45 a. m. During the evening of the 23d and the morning of the 24th, disturbed conditions had overspread the northeast portion of the Gulf of Mexico and the area adjacent to the Georgia and South Carolina coasts. By 7 p. m. of October 24, the disturbance had moved into a trough of low pressure over the New England States.

A succession of accurate advices and warnings was issued from the forecast centers at New Orleans, Jacksonville, and Washington, D. C., covering the progress of this disturbance.

From reports at hand it does not appear that any of these three disturbances developed hurricane force.

No loss of life occurred and but slight property damage was reported in connection with the October disturbances.

[1] The tracks of these disturbances are shown on chart X in this Review.
[2] Eastern standard time is used in this report.

NOTES AND REVIEWS

"Radiosonde" an Officially-Adopted Weather Bureau Term. By L. T. SAMUELS. The term "radiometeorograph" has been used quite generally in this country for designating the instrument which is attached to sounding balloons for transmitting by radio to a ground station the upper-air pressures, temperatures, and humidities during the balloon's flight.

Since the suffix of the above term implies a recording instrument, objection to its use has been made. The substitute term "radiotelemeter" then came into use but objections to this term are likewise valid in that no indication is given as to what is measured, namely, meteorological elements. Therefore, in view of these circumstances and the wide international use of radiometeorograph observations, the Weather Bureau has decided to adopt the term "radiosonde" to designate the instrument which is attached to the sounding balloon in these observations. This term is now similarly used in both French and German literature. Additional terms logically follow: "radiosonde station," "radiosonde observation," "radiosonde record," "radiosonde recorder," etc.

However, since the Federal Communications Commission requirements are that the point from which the radio signals are transmitted must be designated as the station, the term "radio aerological sounding station," instead of "radiosonde," will be used to designate the radiosonde in connection with frequency allocations utilized in this work. In accordance therewith, a "radio aerological sounding station" is defined as a "special radio transmitting station sent aloft for the purpose of obtaining information regarding atmospheric conditions."

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SOLOR OBSERVATIONS

[Meteorological Research Division, Edgar W. Woolard in charge]

SOLAR RADIATION OBSERVATIONS, OCTOBER 1938

By Irving F. Hand

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the Monthly Weather Review, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal, and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities averaged below normal for October at Washington and Madison; above normal at Lincoln. The Blue Hill data for October will be included in the November Review.

Total solar and sky radiation was above normal at all stations for which normals have been completed with the exception of Fresno, Twin Falls, Miami, Riverside, and Friday Harbor.

Polarization measurements made on 7 days at Madison give a mean of 53 percent with a maximum of 64 percent on the 10th. Both of these values are below the corresponding normals for the month.

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TABLE 1.—*Solar radiation intensities during October, 1938*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.					Air mass, P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 1	8.81				0.96						5.79
Oct. 3	5.79			0.96	1.18						5.16
Oct. 4	6.50			.74	1.06		1.08				4.17
Oct. 5	6.76			.74	1.01		.94				8.81
Oct. 8	4.95			1.08	1.24		1.18				8.81
Oct. 10	6.50				1.11		1.10				6.76
Oct. 11	7.87			.74	.89						8.18
Oct. 14	11.38				1.06						11.38
Oct. 17	9.47		0.85	.99	1.13		1.07				9.83
Oct. 18	9.47		.67	.83	.99		.83				9.47
Oct. 19	13.13				.90		1.04				12.68
Oct. 21	5.36	0.58	.63	.76	1.08						5.36
Oct. 22	6.50	.73	.82	.92	1.05						5.79
Oct. 25	4.17	.85	.96	1.06	1.22						3.81
Oct. 26	5.56	.92	1.00	1.10	1.22						6.02
Oct. 27	5.36	.72	.80	.96	1.06						6.02
Oct. 31	5.79	.65	.75	.88	1.14						4.95
Means		.74	.81	.91	1.08		1.03				
Departures		−.01	−.04	−.06	−.05		−.10				

MADISON, WIS.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Oct. 8	10.97	0.29	0.32								10.21
Oct. 10	9.83	.61	.76	0.89	1.02						11.81
Oct. 13	6.02	1.09	1.19	1.31	1.43						5.56
Oct. 14	5.79	.90	.96	1.08							9.47
Oct. 17	8.81				1.15						9.47
Oct. 25	4.95				1.27						6.02
Oct. 26	5.56				1.22						5.56
Oct. 27	5.56				1.11						5.56
Oct. 28	7.32			.88	1.08						7.32
Means		.72	.81	1.04	1.18						
Departures		−.07	−.11	−.01	−.02						

LINCOLN, NEBR.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Oct. 1	9.14	0.33	0.45	0.62	0.87						7.87
Oct. 3	9.14	.58	.72	.90	1.11	1.42	1.04	0.77			7.04
Oct. 4	9.14				.95						8.48
Oct. 5	8.81				.97						9.47
Oct. 7	11.38				1.03	1.29					8.18
Oct. 8	8.81	.53	.63	.78							10.97
Oct. 11	12.24		.72	.92							13.13
Oct. 12	11.81				1.26		1.25	1.09	0.96	0.86	8.18
Oct. 13	7.04	.70	.90	1.12	1.29		1.28	1.09	.90	.70	7.87
Oct. 14	9.83			.98							7.57
Oct. 17	7.29	.68	.83	−.99	1.18	1.47	1.16	.95	.82	.69	7.29
Oct. 18	8.18						1.24	1.06	.90	.77	7.29
Oct. 19	3.99	.95	1.08	1.22	1.37						4.37
Oct. 20	3.15	.99	1.08	1.27	1.40		1.31	1.11	.99	.89	5.56
Oct. 21	3.99	.96	1.14	1.23	1.40	1.65	1.44	1.22	1.12	1.00	3.99
Oct. 22	4.37	1.01	1.11	1.20	1.39						3.81
Oct. 24	1.96	.94	1.06	1.28	1.44	1.65	1.44	1.26	1.12	1.01	2.26
Oct. 25	2.74	.96	1.11	1.22	1.44		1.41	1.21	1.01	.86	3.15
Oct. 26	4.37	.94	1.06	1.10	1.40		1.41	1.24	1.07	.97	3.48
Oct. 27	4.17	.95	1.07	1.23	1.40		1.34	1.16	1.00	.89	4.57
Oct. 31	5.79			.78	1.04						6.76
Means		.81	.93	1.06	1.23	1.50	1.30	1.11	.99	.86	
Departures		−.02	.00	−.03	+.05	+.02	+.04	+.03	+.04	+.03	

TABLE 1.—*Solar radiation intensities during October, 1938*—Contd.

[Gram calories per minute per square centimeter of normal surface]

BLUE HILL, MASS.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.					Air mass, P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 2	5.2				1.25	1.48	1.14	.89	0.70	0.55	5.6
Oct. 3	7.4					1.50	1.21	1.04			5.6
Oct. 4	6.1		0.90			1.41	1.12	.89			5.2
Oct. 5	6.1		.90	1.01	1.20	1.40	1.00	.61			6.3
Oct. 7	4.6					1.37	1.20	1.04			4.6
Oct. 8	4.4		1.06	1.19	1.33	1.48	1.24	1.00	.80		5.6
Oct. 9	4.8		.80	1.02							6.1
Oct. 10	5.8		.89	1.04	1.22	1.42					5.8
Oct. 11	6.1	0.94	1.00	1.07	1.14	1.21	.96	.65			7.4
Oct. 12	9.2			.75	1.00	1.29	1.00				11 5
Oct. 13	10.7	.41	.68	.78	.94	1.13					9.6
Oct. 16	11.5		.69	.94	1.11	1.32					11.9
Oct. 17	8.5			1.10	1.16	1.15					10.3
Oct. 18	6.5		.79	.94	1.11	1.12	1.00				7.6
Oct. 19	9.6						.94				11.9
Oct. 22	5.6				1.15						5.0
Oct. 23	6.2	.76			1.22						5.6
Oct. 26	5.0			1.06	1.26						5.8
Means		.70	.86	.99	1.16	1.33	1.08	.88	.75	.55	
Departures		−.24	−.14	−.12	−.08	−.05	−.12	−.14	−.16	−.21	

LATE DATA—LINCOLN, NEBR.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Sept. 1	12.68			0.96	1.18						11.38
Sept. 2	14.60				1.14						15.11
Sept. 8	16.20			1.05	1.24	1.48	1.20	1.01	0.85	0.73	13.61
Sept. 9	15.11	0.79	0.90	1.01	1.20	1.45			.76	.59	13.61
Sept. 10	16.79		.90	1.02	1.19	1.40					16.79
Sept. 14	11.38							1.01	.91	.81	13.13
Sept. 15	8.81		1.02	1.20							9.47
Sept. 16	7.29		.82	.96			1.24				7.04
Sept. 19	4.57	1.07	1.16	1.27	1.42	1.60	1.40	1.21	1.09	.98	3.99
Sept. 20	4.75	.80	.87	1.09	1.22	1.55	1.27	1.05	.92	.79	5.16
Sept. 21	6.50	.71	.84	1.02	1.20	1.42	1.12	.91	.75	.61	6.76
Sept. 22	7.87	.72	.83	.95	1.22		1.23	1.00	.86	.69	8.81
Sept. 23	8.48		.91	1.08	1.23		1.20	.99	.82	.73	7.29
Sept. 26	11.81	.58	.71								10.21
Sept. 27	8.18			.72	.78						6.76
Sept. 28	6.76	.44	.54	.67	.92		.98	.78	.62	.47	6.76
Sept. 29	6.76			.72	.95		1.03	.87	.69	.58	8.48
Sept. 30	8.81	.72	.85	.96	1.22		.87	.76	.60	.49	10.59
Means		.73	.86	.98	1.15	1.48	1.15	.96	.81	.68	
Departures		.00	+.02	+.01	+.02	+.06	−.01	−.02	−.03	+.05	

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

Gram-calories per square centimeter

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 1	369	276	406	293	394	388	166	279	448	365	444	402	374	559	209	328	380
Oct. 8	336	306	339	324	314	362	92	258	361	332	336	324	336	517	186	264	366
Oct. 15	308	223	385	277	274	382	92	214	425	397	343	365	282	508	278	221	284
Oct. 22	216	240	333	252	189	303	60	280	309	372	443	358	216	526	150	156	251
	Departures of daily totals from normals																
Oct. 1	+36	+1	+65	+48	+107	−45	+49	−97	+54	−38	+95	+22	+47	+55	−56	+57	
Oct. 8	+31	+60	+33	+105	+48	−39	+5	−101	−2	−37	−6	−42	+11	+32	−48	+5	
Oct. 15	+25	+4	+88	+81	+55	+8	+22	−113	+65	+34	+32	+20	−10	+51	+77	−10	
Oct. 22	−40	+33	+52	+79	−3	−58	−1	−15	−46	−20	+116	−1	−5	+74	−5	+30	
	Accumulated departures since Jan. 1																
	−11,260	−1,309	+1,652	+19,926	+4,291	−2,842	+4,844	−8,729	−2,128	−5,534	+7,644	−5,997	−2,581	+12,992	+7,084	+1,470	

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Mt. Wilson group No.	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot or group	Area: Total for each day	Spot count	Observatory
1938	h m		°	°	°				
Oct. 1	11 16	6130	−42.5	38.4	+20.0	145	....	11	U. S. Naval.
		6131	−42.0	38.9	−17.0	97	....	1	
		6127	−13.0	67.9	−8.0	24	....	5	
		6125	−7.0	73.9	+13.5	73	....	12	
		6121	+23.0	103.9	+14.0	73	....	10	
		6116	+50.0	130.9	−14.0	24	....	4	
		6123	+53.0	133.9	+18.0	24	....	4	
		6123	+63.0	143.9	+17.0	170	....	1	
		6112	+59.0	139.9	−12.0	485	....	6	
		6111	+84.0	164.9	−11.0	291	1,406	2	
Oct. 2	11 28	6130	−29.0	38.6	+20.0	170	....	14	Do.
		6131	−29.0	38.6	−17.5	73	....	2	
		6133	−11.0	56.6	−12.0	12	....	5	
		6127	0.0	67.6	−8.0	36	....	9	
		6132	0.0	67.6	−12.0	6	....	3	
		6125	+7.0	74.6	+14.0	48	....	17	
		6121	+35.0	102.6	+15.0	36	....	18	
		6116	+63.0	130.6	−14.5	6	....	2	
		6112	+70.0	137.6	−12.5	121	....	2	
		6112	+72.0	139.6	−11.0	315	....	2	
		6123	+78.0	145.6	+17.0	121	944	2	
Oct. 3	10 55	6131	−17.0	37.7	−17.5	73	....	4	Do.
		6130	−16.5	38.2	+20.0	218	....	15	
		6133	+2.0	56.7	−11.0	16	....	4	
		6127	+10.0	64.7	−8.0	6	....	2	
		6125	+12.5	67.2	+13.0	12	....	11	
		6125	+23.0	77.7	+13.0	36	....	9	
		6132	+14.0	68.7	−13.0	12	....	2	
		6121	+51.0	105.7	+14.0	24	....	8	
		6112	+89.0	143.7	−12.0	36	433	1	
Oct. 4	10 58	6137	−61.0	340.5	+5.0	12	....	2	Do.
		6136	−11.5	30.0	+11.0	121	....	21	
		6130	−3.0	38.5	+20.0	121	....	17	
		6131	−3.0	38.5	−17.0	78	....	2	
		6135	+15.0	56.5	+11.0	6	....	1	
		6133	+15.5	57.0	−11.0	6	....	1	
		6125	+27.0	68.5	+13.0	6	....	11	
		6125	+35.0	76.5	+13.0	73	....	4	
		6132	+28.0	69.5	−14.0	12	....	3	
		6121	+65.0	106.5	+14.0	36	....	7	
		6134	+78.0	119.5	+11.0	97	563	7	
Oct. 5	11 7	6141	−84.0	304.2	+17.0	2,424	....	22	Do.
		6137	−48.0	340.2	+5.0	36	....	2	
		6136	+2.0	30.2	+11.0	436	....	32	
		6140	+7.5	35.7	+13.0	12	....	4	
		6130	+10.0	38.2	+19.5	145	....	7	
		6131	+10.0	38.2	−17.5	48	....	1	
		6139	+23.5	51.7	−17.5	24	....	4	
		6132	+42.0	70.2	−15.0	6	....	2	
		6125	+48.0	76.2	+12.0	145	....	14	
		6138	+65.0	93.2	−21.5	24	3,300	2	
Oct. 7	10 38	6141	−57.0	305.1	+17.0	2,909	....	75	Do.
		6142	−5.0	357.1	+8.0	36	....	2	
		6136	+27.0	29.1	+11.0	267	....	20	
		6131	+33.0	35.1	−17.5	85	....	8	
		6140	+36.0	38.1	+13.0	48	....	6	
		6130	+39.0	41.1	+19.0	73	....	2	
		6139	+48.0	50.1	−16.5	24	....	3	
		6125	+71.5	73.6	+11.5	6	3,448	2	
Oct. 8	10 48	6143	−87.0	261.8	−7.0	145	....	1	Do.
		6141	−44.0	304.8	+17.0	3,054	....	175	
		6142	+9.0	357.8	+7.0	97	....	10	
		6136	+40.0	28.8	+10.0	145	....	25	
		6131	+47.0	35.8	−18.0	48	....	3	
		6140	+49.5	38.3	+13.0	97	....	15	
		6130	+51.0	39.8	+19.0	97	....	2	
		6139	+63.5	52.3	−18.5	24	3,707	4	
Oct. 9	9 22	6143	−75.0	261.4	−7.0	242	....	3	Mt. Wilson.
		6145	−43.0	293.4	+15.0	6	....	1	
		6141	−32.0	304.4	+17.0	3,054	....	66	
		6144	−5.0	331.4	+12.5	48	....	4	
		6142	+20.0	356.4	+8.5	97	....	13	
		6136	+52.0	28.4	+10.5	170	....	12	
		6131	+60.0	36.4	−18.5	12	....	1	
		6140	+63.0	39.4	+13.0	145	....	7	
		6130	+65.0	41.4	+19.0	97	....	1	
		6139	+76.5	52.9	−18.5	24	3,895	2	
Oct. 10	10 58	6143	−60.0	262.3	−8.0	242	....	11	U. S. Naval.
		*	−37.0	285.3	+7.0	24	....	4	
		6145	−27.0	295.3	+14.0	24	....	4	
		6141	−17.0	305.3	+17.0	3,054	....	210	
		6144	+10.0	332.3	+11.0	73	....	5	
		6142	+37.0	359.3	+7.5	73	....	10	
		6146	+67.0	29.3	+27.0	61	....	5	
		6136	+70.0	32.3	+11.0	145	....	7	
		6140	+77.0	39.3	+13.0	36	3,732	4	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot or group	Area: Total for each day	Spot count	Observatory
1938	h m		°	°	°				
Oct. 11	11 0	6143	−47.0	262.1	−8.0	242	....	9	U. S. Naval.
		6145	−14.0	295.1	+13.5	24	....	2	
		6141	−4.0	305.1	+17.0	2,957	....	230	
		6144	+25.0	334.1	+11.0	48	....	9	
		6142	+50.0	359.1	+7.5	48	....	5	
		6147	+60.0	9.1	−22.0	6	....	2	
		6146	+78.0	27.1	+27.0	24	....	1	
		6136	+83.0	32.1	+10.5	73	3,422	2	
Oct. 12	11 31	6149	−76.0	219.6	+24.5	12	....	3	Do.
		6148	−41.0	254.6	−11.5	6	....	1	
		6143	−33.0	262.6	−7.0	145	....	6	
		6145	+2.0	297.6	+12.0	97	....	5	
		6141	+8.0	303.6	+17.0	2,957	....	110	
		6144	+39.5	335.1	+11.0	145	....	9	
		6142	+64.5	0.1	+7.5	12	....	2	
		6147	+74.0	9.6	−22.0	12	3,386	1	
Oct. 13	11 12	6149	−62.0	220.6	+24.5	12	....	4	Do.
		6151	−53.0	229.6	−7.0	36	....	9	
		6148	−27.0	255.6	−11.5	6	....	1	
		6143	−18.0	264.6	−7.0	121	....	7	
		6145	+15.0	297.6	+12.0	48	....	5	
		6141	+21.0	303.6	+17.0	2,957	....	215	
		6144	+53.0	335.6	+11.5	97	3,277	8	
Oct. 14	11 52	6149	−49.0	220.1	+24.5	24	....	6	Do.
		6151	−39.0	230.1	−7.0	36	....	10	
		6143	−3.5	265.6	−7.0	73	....	6	
		6150	+7.0	276.1	+11.0	24	....	1	
		6145	+27.0	296.1	+13.0	24	....	10	
		6141	+35.0	304.1	+17.0	2,715	....	175	
		6144	+67.0	336.1	+11.0	97	2,993	6	
Oct. 15	10 22	6149	−35.0	221.7	+25.5	24	....	5	Do.
		6151	−26.0	230.7	−7.0	36	....	12	
		6143	+10.0	266.7	−6.5	61	....	4	
		6145	+40.0	296.7	+13.0	24	....	6	
		6141	+48.0	304.7	+17.0	2,715	2,860	190	
Oct. 16	12 13	6152	−63.0	179.5	+26.0	48	....	2	Do.
		6148	+14.0	256.5	−12.0	48	....	7	
		6143	+25.0	267.5	−6.5	36	....	4	
		6141	+60.0	302.5	+17.0	2,424	2,556	60	
Oct. 17	12 44	6152	−48.0	181.0	+26.0	36	....	6	Do.
		6148	+29.0	258.0	−11.0	97	....	10	
		6143	+38.5	267.5	−6.5	12	....	4	
		6141	+75.0	304.0	+17.0	1,697	1,842	60	
Oct. 18	11 20	6154	−78.0	138.6	−11.0	194	....	2	Do.
		6152	−34.0	182.6	+25.0	6	....	2	
		6153	−31.0	185.6	−8.0	12	....	3	
		6148	+43.5	260.1	−10.5	48	....	8	
		6141	+85.0	301.6	+17.0	291	551	5	
Oct. 19	11 19	6155	−84.0	119.4	+12.5	242	....	3	Do.
		6154	−63.0	140.4	−11.0	194	....	2	
		6148	+56.0	259.4	−11.0	291	727	20	
Oct. 20	11 2	6155	−70.0	120.4	+12.5	291	....	4	Do.
		6156	−69.0	121.4	+24.5	121	....	6	
		6154	−50.0	140.4	−11.0	194	....	1	
		6148	+69.0	259.4	−10.5	242	848	13	
Oct. 21	11 35	6155	−58.0	118.9	+12.0	242	....	4	Do.
		6156	−54.0	122.9	+24.0	388	....	9	
		6154	−37.0	139.9	−11.0	194	....	2	
		6157	+47.0	223.9	+26.0	6	830	2	
Oct. 22	11 3	6155	−45.0	119.0	+12.0	242	....	8	Do.
		6156	−40.0	124.0	+24.0	291	....	27	
		6154	−24.0	140.0	−11.0	194	....	2	
		6158	+7.0	171.0	+11.0	61	888	8	
Oct. 23	14 58	6160	−45.0	103.7	−16.0	24	....	3	Mt. Wilson.
		6155	−31.0	117.7	+12.0	158	....	8	
		6156	−26.0	122.7	+24.0	291	....	28	
		6154	−9.5	139.2	−11.0	194	....	2	
		6158	+20.0	168.7	+12.0	85	....	6	
		6159	+25.0	173.7	+28.0	24	776	3	
Oct. 24	15 41	6160	−30.0	105.1	−16.0	61	....	10	Do.
		6155	−16.0	119.1	+13.0	194	....	20	
		6156	−11.0	124.1	+24.0	339	....	17	
		6154	+5.0	140.1	−10.5	121	....	3	
		6158	+37.0	172.1	+13.0	36	....	4	
		6161	+41.0	176.1	+8.0	12	763	1	
Oct. 25	11 55	6164	−80.0	44.0	+14.0	194	....	2	U. S. Naval.
		6163	−20.0	104.0	−23.0	24	....	3	
		6160	−18.0	106.0	−16.0	145	....	15	
		6162	−8.5	115.5	−20.0	12	....	3	
		6155	−3.0	121.0	+14.0	121	....	18	
		6156	+1.0	125.0	+25.0	291	....	27	
		6154	+16.0	140.0	−11.0	97	....	3	
		6158	+47.0	171.0	+11.0	12	896	2	
Oct. 26	12 27	6168	−77.0	33.5	+25.0	194	....	4	Do.
		6164	−66.0	44.5	+14.0	121	....	1	
		6163	−8.0	102.5	−23.0	24	....	4	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot or group	Area: Total for each day	Spot count	Observatory
1938	*h m*		°	°	°				
Oct. 26	12 27	6166	−8.0	102.5	−11.0	170	-------	20	U. S. Naval.
		6160	−3.0	107.5	−15.0	388	-------	28	
		6155	+9.5	120.0	+13.0	73	-------	9	
		6156	+13.0	123.5	+25.0	194	-------	9	
		6154	+30.0	140.5	−11.0	97	-------	2	
		6158	+61.0	173.5	+11.5	12	1,273	1	
Oct. 27	11 14	6171	−73.0	25.0	+9.0	12	-------	2	Do.
		6168	−64.0	34.0	+26.0	133	-------	5	
		6164	−53.0	45.0	+15.0	182	-------	2	
		6167	−17.0	81.0	−31.0	24	-------	4	
		6163	+5.0	103.0	−25.0	48	-------	10	
		6166	+5.0	103.0	−11.0	242	-------	8	
		6165	+8.0	106.0	−19.0	12	-------	2	
		6160	+11.0	109.0	−15.0	388	-------	20	
		6155	+21.0	119.0	+12.0	48	-------	6	
		6156	+26.0	124.0	+25.0	315	-------	12	
		6154	+41.0	139.0	−11.0	73	1,477	3	
Oct. 28	11 4	6175	−79.0	5.9	+18.0	36	-------	3	Mt. Wilson.
		6171	−60.0	24.9	+10.0	73	-------	13	
		6168	−50.0	34.9	+26.0	242	-------	20	
		6164	−40.5	44.4	+14.0	109	-------	2	
		6174	−22.0	62.9	−15.0	12	-------	5	
		6170	−6.5	78.4	−12.0	61	-------	12	
		6167	−6.0	78.9	−32.0	12	-------	2	
		6173	−4.0	80.9	+13.0	12	-------	2	
		6169	−2.0	82.9	+9.0	48	-------	13	
		6166	+19.0	103.9	−11.0	194	-------	16	
		6163	+20.0	104.9	−22.0	109	-------	12	
		6160	+25.0	109.9	−15.0	388	-------	40	
		6172	+27.0	111.9	−2.0	6	-------	1	
		6155	+35.0	119.9	+13.0	48	-------	6	
		6156	+39.0	123.9	+25.0	291	-------	18	
		6154	+56.0	140.9	−11.0	48	1,689	3	
Oct. 29	14 21	6177	−78.0	351.9	+11.0	145	-------	2	U. S. Naval.
		6176	−73.0	356.9	−9.0	242	-------	4	
		6175	−63.0	6.9	+17.0	61	-------	3	
		6171	−45.0	24.9	+10.0	12	-------	1	
		6168	−37.0	32.9	+26.0	291	-------	23	
		6164	−26.5	43.4	+14.0	121	-------	1	
		6167	+9.5	79.4	−31.5	24	-------	2	
		6173	+10.0	79.9	+15.0	97	-------	2	
		6169	+12.0	81.9	+9.5	61	-------	6	
		6163	+34.0	103.9	−22.5	194	-------	16	
		6166	+34.0	103.9	−11.0	145	-------	10	
		6160	+41.0	110.9	−14.0	388	-------	15	
		6172	+41.5	111.4	−3.0	24	-------	1	
		6156	+51.0	120.9	+27.0	121	-------	6	
		6154	+70.0	139.9	−11.0	6	1,932	1	
Oct. 30	11 33	6177	−65.0	353.2	+11.0	145	-------	4	Do.
		6176	−61.0	357.2	−9.0	218	-------	4	
		6175	−53.0	5.2	+19.0	121	-------	8	
		6171	−35.0	23.2	+10.0	12	-------	2	
		6168	−25.0	33.2	+26.0	291	-------	16	
		6164	−15.0	43.2	+15.0	121	-------	4	
		6179	+6.0	64.2	+16.0	6	-------	1	
		6167	+23.0	81.2	−30.5	12	-------	1	
		6173	+23.0	81.2	+16.0	97	-------	7	
		6169	+24.0	82.2	+9.5	24	-------	4	
		6178	+35.0	93.2	+17.0	6	-------	1	
		6163	+45.0	103.2	−23.0	315	-------	23	
		6166	+49.0	107.2	−11.0	97	-------	4	
		6160	+53.0	111.2	−13.5	485	-------	28	
		6172	+53.0	111.2	−3.0	24	-------	4	
		6156	+64.0	122.2	+27.0	194	2,168	2	
Oct. 31	11 12	6180	−64.0	341.2	−4.5	36	-------	3	U. S. Naval.
		6177	−52.0	353.2	+11.0	97	-------	3	
		6176	−50.0	355.2	−9.0	218	-------	10	
		6175	−39.0	6.2	+18.0	85	-------	4	
		6181	−24.0	21.2	−12.0	6	-------	4	
		(*)	−16.0	29.2	+14.0	6	-------	1	
		6168	−11.0	34.2	+24.5	315	-------	39	
		6164	−1.0	44.2	+14.5	121	-------	2	
		6173	+37.0	82.2	+15.0	121	-------	3	
		6163	+58.0	103.2	−23.0	315	-------	14	
		6166	+63.0	108.2	−11.0	48	-------	1	
		6160	+65.0	110.2	−13.0	388	-------	12	
		6156	+78.0	123.2	+27.0	194	1,950	3	

Mean daily area for 30 days—1,951. *Not numbered.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR OCTOBER 1938

[Dependent alone on observations at Zurich, Switzerland]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

October 1938	Relative numbers	October 1938	Relative numbers	October 1938	Relative numbers
1	----------	11	----------	21	55
2	94	12	134	22	46
3	55	13	121	23	*EC* 61
4	*Mac* ----	14	122	24	*a* --
5	*Macd* 15	15	103	25	*aa* 91
6	*Mc* 102	16	78	26	*ad* 104
7	92	17	*Mc* 71	27	--------
8	102	18	*d* 31	28	*Mc* ---
9	*d* 143	19	20	29	*ad* 148
10	152	20	*Ecd* 58	30	--------
				31	*a* 155

Mean, 24 days=93.5.

October 17. Middle large bright chromospheric eruption at $9^h\ 43^m$ to $9^h\ 59^m$ U. T., W.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

During October 1938 a total of 523 aerological observations were made by airplane and radiosonde at 18 points in the United States. The mean free-air data based on these observations are given in tables 1 and 1a. They include the basic meteorological elements of pressure, temperature, and relative humidity, recorded at certain geometric heights. At four stations a maximum height of 21 kilometers was reached during 31 radiosonde observations, while all of the 309 observations listed in table 1a reached a height of 16 kilometers.

The "means" are omitted whenever less than 15 observations are made at the surface and less than 5 at a standard height, but 15 observations are required for those levels that come within the upper and lower limits of the monthly vertical range of the tropopause. A brief description of the methods used for computing these means will be found under "Aerological Observations" in the January 1938 issue of the MONTHLY WEATHER REVIEW.

The month of October was abnormally warm, as shown by chart 1. The mean *surface* temperatures (°F.) were above normal throughout the entire United States, with only minor exceptions along the south Atlantic coast, and in Florida and portions of California. East of the Mississippi River and west of the Rocky Mountains, the departures of mean surface temperature above the normal were moderate, but in the central States and upper Missouri valley the mean temperatures were in excess by as much as 10° F. above the normal. These positive

departures in October showed a continuance of the tendency existing throughout the summer and fall months of 1938 for the surface temperature to range considerably above the normal.

Mean free-air temperatures (° C.) recorded *above* the surface over the United States during October at all stations were seasonally lower than those noted in the preceding month of September, except over Sault Ste. Marie, Mich., at 3 kilometers. The highest mean temperatures were confined generally to the southern half of the country, but a warm area pushed northward as far as Omaha, Nebr. The highest October means for the country, as recorded at each level, were noted over Pensacola, Fla. (18.2° C.); Oklahoma City, Okla. (18.3° C.); El Paso, Tex. (18.3° C., 15.4° C., 11.9° C., and 8.1° C.); and over Pensacola, Fla. (0.2° C. and −5.8° C.); at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. The lowest mean tempertures of 6.8° C., 6.0° C., 5.2° C., 3.9° C., 1.9° C., −6.0° C., and −12.4° C., occurred over Sault Ste. Marie, Mich., at 0.5, 1, 1.5, 2, 2.5, 4, and 5 kilometers, respectively, while the lowest at 3 kilometers (−0.1° C.) was reported over Seattle, Wash.

Mean temperatures were decidedly lower during the current month at all levels over Seattle and Spokane, Wash., than those recorded in September when the same two stations reported exceptionally warm means at all levels. Over Spokane, Wash., the mean temperatures in October were lower than in September by 10.0° C., 9.5° C., 8.5° C., 7.2° C., 6.0° C., 4.3° C., and 3.4° C., at 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. However, over Sault Ste. Marie, Mich., Chicago, Ill., Nashville, Tenn., and Omaha, Nebr., the mean temperatures for October at each level were only slightly lower than those recorded in the preceding month of September.

In the high altitudes above 5 kilometers, where records were obtained only by radiosonde, the lowest mean temperature for the United States was −65.2° C., over Oklahoma City, Okla., at 17 kilometers. Slightly higher mean minimum temperatures (−60.6° C. and −62.4° C.) were recorded farther north over Sault Ste. Marie, Mich., and Fargo, N. Dak. All of the lowest mean temperatures for all stations were recorded along the 17-kilometer level as was also the case during the preceding month of September. A gradual increase in the mean temperature occurred upward above 17 kilometers, to as much as −60.4° C. over Oklahoma City, Okla., at 21 kilometers. This was the lowest recorded at the highest altitude reached in October. However, temperatures for the current month were slightly higher in the high altitudes than those recorded during September at corresponding levels.

Isobaric charts prepared from the mean pressure data given in tables 1 and 1a, showed that during October a statistical low pressure area existed in the lower levels over Fargo, N. Dak. In the higher levels this area extended east and west over the entire northern tier of States, but was centered over Sault Ste. Marie, Mich. Pressure, however, in the higher altitudes reached by radiosondes, continued lower over Fargo, N. Dak., as well as Sault Ste. Marie, Mich. Pressure was relatively low over the far Northwest, but it was high over the southern States at all levels with the center apparently over Pensacola, Fla. Mean pressures recorded over the country in October showed little difference from those noted during September, but they were slightly lower over the South in the upper levels, and decidedly lower over Fargo, N. Dak., at all levels.

High relative humidities prevailed during October over most of the Far West, the Pacific coast, and the Northeast, particularly over Spokane, Wash., and Sault Ste. Marie, Mich., at all levels. This distribution coincided closely with those sections of the United States that showed high percentages of normal precipitation for October, but differed from that condition which existed in the previous month of September when high humidities were found over the eastern half of the country. The highest mean humidity for the United States was recorded over Sault Ste. Marie, Mich., at all levels. It diminished steadily from 90 percent at the surface to 56 percent at 5 kilometers, and 47 percent at 9 kilometers. El Paso, Tex., reported the lowest humidity recorded in the lower levels (39 percent), but this was increased to 60 percent at 4 kilometers. Over Norfolk, Va., the lowest humidity reported at all levels above 2 kilometers (32 percent at 4 kilometers) was noted. This situation held generally over most of the rest of the South and Southeast. But at Omaha, Nebr., while mean relative humidities were comparatively high at all levels, that State reported the smallest amount of precipitation of any during October (11 percent of normal).

Resultant winds in the free atmosphere, based on pilot-balloon observations made near 5 a. m. (75th meridian time), are shown in table 2. The resultant wind directions remained much closer to their normals during the month of October than in the preceding month of September when unusually wide divergences were noted. However, there were several outstanding departures in resultant velocities from normal observed in October, but these were mostly less than normal and confined generally to the 3- and 4-kilometer levels.

The outstanding departures or differences between the October resultant directions and their normals in each level over the United States were: 163° at Medford, Oreg. (when the October direction is rotated in a clockwise direction away from its normal); 119°, 87°, 82°, 96°, and 86° (when rotated counterclockwise) over Oakland, Calif.; 162° (counterclockwise) and 153° (clockwise) over Key West, Fla.; and 75° (counterclockwise) over Spokane, Wash.; at the surface, 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively.

The greatest departures of the resultant directions from normal at all levels were noted over Oakland, Calif.; Key West, Fla.; Medford, Oreg.; Atlanta, Ga.; San Diego, Calif.; and Nashville, Tenn. Over Oakland, Calif., the October resultant directions were 158°, 235°, 278°, 270°, 244°, 246°, 251°, 305°, and 332°, as compared to the established normals of 156°, 354°, 5°, 352°, 340°, 332°, 294°, 272°, and 313°, at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. As previously recorded for several months in 1938, the stations at St. Louis, Mo.; Chicago, Ill.; and Oklahoma City, Okla., again showed the least departures from the October resultant directions and their normals at all levels.

Farther north, at Medford, Oreg., the greatest departures occurred at the surface and at 0.5 kilometer, where the differences were 163° and 113°, when rotated in a clockwise direction. Above these levels the differences were much less, and the monthly resultants departed in an opposite direction with a counterclockwise rotation away from normal. In the South, over Atlanta, Ga.; Nashville, Tenn.; and Pensacola, Fla., decided variations from normal were noted in the upper levels. Above 1.5 kilometers they departed widely from normal in a clockwise direction so that the winds were northerly. Atlanta, Ga.; showed outstanding departures at all levels. These differences were: 10°, 25°, 26°, 62°, 45°, 53°, 67°, 64°, and 68°, departing in a clockwise direction northward from normal,

at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively.

The distribution of resultant wind directions over the United States at all levels during October showed that, above the surface, the winds were almost generally from a westerly direction. At 1.5 kilometers 45 percent of the winds fell in the northwest quadrant, 32 percent in the southwest, 14 percent in the southeast, and 9 percent in the east. Of all the winds having westerly components those from the northwest quadrant predominated slightly at all levels up to 4 kilometers. At 5 kilometers, however, 50 percent of the winds were southwesterly, 37 percent northwesterly, and 13 percent northeasterly. A small percentage of the directions fell in the northeast quadrant at all of the levels from 0.5 to 5 kilometers.

Over San Diego, Calif., Seattle, Wash., Albuquerque, N. Mex., and Cheyenne, Wyo., the current wind directions departed from normal by turning in a counterclockwise rotation at all levels, while over Atlanta, Ga. (as explained), Boston, Mass., and Brooklyn, N. Y., the winds departed from normal by rotating in clockwise directions. The departures in direction at each level over all pilot-balloon stations were nearly equally divided—56 percent having counterclockwise rotations away from their normals, and the average station departure from normal for each level showed there was a steady increase in the departure differences with altitude. These average differences (all stations) between the current resultant directions and the normals for each level were: 26°, 38°, 24°, 25°, 29°, 32°, 35°, 44°, and 47°, at the surface, and at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. The 2-kilometer level showed the most consistent departure in direction, for 63 percent of all stations recorded departures that rotated counterclockwise from their normals.

Resultant wind velocities during October were less than normal at Boston, Mass., by negative differences of 0.3, 2.3, 3.8, 3.2, 4.0, 3.7, 2.7, and 5.6 meters per second, at the surface, and at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. This station showed more negative departures at all consecutive levels than any other station in the country. Billings, Mont., Chicago, Ill., Detroit, Mich., Spokane, Wash., and St. Louis, Mo., reported smaller negative departures at all levels. No station showed positive (or greater than normal) velocity departures at all levels, but at Pensacola, Fla., Salt Lake City, Utah, and San Diego, Calif., large positive departure differences were recorded at most of the levels. In this respect, Pensacola, Fla., indicated the greatest positive differences for the country of 1.1, 3.0, 3.4, 2.7, 0.8, and 1.4 meters per second, at 0.5, 1, 1.5, 2, 2.5, and 4 kilometers, respectively. Light velocities, as well as slight departures from the resultant velocity normals, occurred at Oakland, Calif., Fargo, N. Dak., Nashville, Tenn., Key West, Fla., and Atlanta, Ga. Several of these stations showed, as a result, outstanding resultant direction departures from normal.

Maximum wind velocities for October, as shown in table 3, occurred at a number of stations over the United States. Winds having a speed of 50 meters per second or more (114 miles per hour or more) were reported from Las Vegas, Nev., Greensboro, N. C., Evansville, Ind., Billings, Mont., Denver, Colo., and Albuquerque, N. Mex., at different levels. The highest velocity reported was 78.0 m. p. s. (174 miles per hour) from the SW., over Denver, Colo., in the 17th, at 8 kilometers. The greatset velocity recorded nearest the surface was 34.8 m. p. s. over Medford, Oreg., at 0.8 kilometer, and that at the greatest altitude reached was 59.2 m. p. s. over Albuquerque, N. Mex., at 14 kilometers.

TABLE 1.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by airplanes during October 1938*

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of obs.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.
Billings, Mont. (1,090 m)	29	893	8.8	64							850	11.1	53	800	8.8	52	753	5.9	53	708	2.6	54	625	−3.2	55	550	−9.8	52
Cheyenne, Wyo. (1,873 m)	31	814	5.7	64										802	9.0	54	754	8.6	46	710	5.3	44	627	−1.7	48	552	−9.2	50
Chicago, Ill. (187 m)	31	996	10.1	78	960	13.5	65	905	12.1	62	852	10.6	56	802	8.6	52	755	6.0	50	710	3.0	49	626	−3.8	50	551	−10.5	47
Coco Solo, C. Z.[1] (15 m)	29	1,009	24.5	93	954	23.2	83	902	20.6	84	851	18.0	82	802	15.4	82	756	12.9	80	712	10.5	75	631	4.9	75	558	−0.7	74
El Paso, Tex. (1,193 m)	31	883	14.2	50							852	18.3	39	803	15.4	40	757	11.9	44	713	8.1	47	631	0.0	60	555	−6.3	51
Lakehurst, N. J.[1] (39 m)	27	1,014	9.6	88	960	12.2	64	904	9.5	57	851	6.8	56	801	5.2	47	752	2.8	41	707	0.2	39	624	−6.0	37			
Norfolk, Va.[1] (10 m)	17	1,020	12.5	84	962	13.4	63	906	10.5	57	854	9.2	51	804	7.8	43	757	5.9	35	712	3.5	33	628	−2.3	32	553	−9.2	31
Pearl Harbor, T. H.[1] (6 m)	31	1,015	22.8	82	959	22.5	73	905	19.5	77	854	17.0	74	805	15.1	66	758	13.7	52	715	11.8	47	634	7.8	31	561	3.7	24
Pensacola, Fla.[1] (13 m)	31	1,018	14.9	91	961	18.2	65	907	15.6	62	855	13.0	60	805	10.5	54	758	8.1	50	713	5.4	47	631	0.2	41	556	−5.8	34
St. Thomas, V. I.[1] (8 m)	31	1,014	27.6	78	959	24.2	88	906	21.5	83	855	18.8	79	806	16.2	78	760	14.0	71	717	11.4	65	635	5.9	58	561	0.1	50
Salt Lake City, Utah (1,288 m)	31	872	8.6	70							850	12.1	54	801	9.9	51	754	6.9	51	709	3.5	53	626	−2.9	55	551	−9.0	54
San Diego, Calif.[1] (10 m)	31	1,015	14.1	88	958	15.2	80	903	15.3	68	851	13.1	61	802	10.7	56	754	8.0	53	710	5.5	48	628	−0.2	43	553	−7.6	41
Seattle, Wash.[1] (10 m)	19	1,017	12.2	74	960	12.1	62	904	9.9	56	851	7.7	48	800	5.1	44	752	2.3	43	707	−0.4	40						
Spokane, Wash. (597 m)	31	948	7.4	84				903	9.6	69	850	7.7	67	800	5.0	66	752	2.4	64	706	−0.1	60	623	−4.9	52	548	−10.3	50

[1] Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5-standard-level observations.

TABLE 1a.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by radiosonde during October 1938*

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																											
	Fargo, N. Dak. (274 m)				Nashville, Tenn. (180 m)				Oakland, Calif. (2 m)				Oklahoma City, Okla. (391 m)				Omaha, Nebr. (300 m)				Sault Ste. Marie, Mich. (221 m)				Washington, D. C. (13 m) [1]			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	31	982	7.0	73	31	998	11.0	80	30	1,016	12.7	84	31	972	14.2	61	31	982	11.8	71	31	992	6.2	90	29	1,019	10.0	88
500	31	956	10.4	69	31	962	15.9	60	30	958	13.9	73	31	960	16.6	58	31	959	14.6	61	31	959	6.8	85	29	961	10.4	73
1,000	31	901	10.5	61	31	906	14.4	54	30	903	12.8	62	31	906	18.3	50	31	905	15.6	52	31	902	6.0	79	29	905	8.3	70
1,500	31	848	8.8	56	31	854	11.7	52	30	851	10.8	56	31	851	15.6	49	31	853	13.1	50	31	849	5.2	73	29	852	6.1	67
2,000	31	798	7.0	51	31	804	9.6	47	30	801	8.0	53	31	805	12.2	50	31	803	10.3	50	31	798	3.9	66	29	801	4.8	59
2,500	31	751	4.6	49	31	757	7.1	45	30	754	5.4	48	31	758	8.7	51	31	756	7.5	49	31	750	1.9	65	29	753	3.3	52
3,000	31	706	1.7	49	31	712	4.5	43	30	708	2.7	46	31	713	5.4	48	30	711	4.4	49	31	705	0.6	62	29	708	0.9	50
4,000	31	622	−4.6	50	31	629	−1.2	41	30	625	−3.0	43	31	630	−0.7	43	30	628	−2.8	51	31	622	−6.0	56	29	624	−4.5	44
5,000	31	548	−11.4	52	31	555	−7.2	40	30	551	−9.3	40	31	555	−6.8	39	30	553	−9.0	47	31	546	−12.4	56	29	548	−10.8	41
6,000	31	480	−18.4	51	31	487	−14.0	36	30	483	−15.9	39	31	488	−14.0	36	30	485	−15.5	45	31	478	−18.8	51	28	480	−17.6	38
7,000	31	419	25.4	47	31	426	−21.0	36	29	422	−22.8	41	30	427	−21.3	34	30	424	−22.5	43	31	418	−25.6	48	28	420	−24.3	36
8,000	31	364	−32.7	44	30	371	−28.0	36	28	368	−29.4	39	30	372	−28.3	34	30	370	−29.8	43	31	364	−33.1	48	28	366	−30.8	34
9,000	31	315	39.9	41	30	322	−35.3	36	27	319	−36.5	39	30	323	−35.5	33	30	320	−36.6	43	30	315	−39.7	47	28	317	−37.1	----
10,000	31	272	−46.8	----	29	279	−42.0	----	26	276	−43.2	----	30	279	−42.6	----	30	277	−43.2	----	29	271	−45.9	----	27	274	−43.2	----
11,000	29	233	−53.0	----	28	240	−48.0	----	25	237	−49.2	----	29	240	−48.7	----	30	239	−49.7	----	29	233	−51.5	----	26	236	−48.5	----
12,000	28	199	−57.6	----	28	206	−53.1	----	25	203	−53.3	----	28	206	−54.1	----	30	204	−54.2	----	29	200	−55.3	----	26	202	−52.5	----
13,000	26	170	−60.3	----	28	176	−56.1	----	24	174	−55.8	----	27	176	−57.8	----	30	174	−57.5	----	29	171	−57.7	----	25	174	−55.8	----
14,000	25	144	−60.7	----	27	150	−58.3	----	24	148	−58.1	----	27	150	−60.7	----	30	149	−60.0	----	29	146	−58.9	----	23	148	−58.4	----
15,000	24	123	−61.4	----	25	128	−60.5	----	22	126	−60.1	----	27	127	−63.3	----	28	126	−62.0	----	27	124	−59.7	----	14	126	−60.3	----
16,000	23	105	−62.3	----	23	109	−61.8	----	20	107	−61.1	----	25	108	−64.7	----	27	107	−62.1	----	26	106	−60.2	----	8	107	−60.8	----
17,000	23	88	−62.4	----	22	93	−62.3	----	19	91	−61.0	----	22	92	−65.2	----	22	91	−62.4	----	23	90	−60.6	----	----	----	----	----
18,000	22	75	−61.9	----	19	79	−61.2	----	16	77	−60.4	----	21	78	−64.2	----	17	78	−61.8	----	21	77	−60.5	----	----	----	----	----
19,000	14	64	−61.3	----	15	67	−60.1	----	12	65	−59.4	----	19	67	−62.9	----	9	66	−60.5	----	16	66	−60.1	----	----	----	----	----
20,000	10	54	−60.3	----	13	57	−59.0	----	11	56	−58.6	----	14	57	−61.6	----	8	56	−58.9	----	12	56	−60.0	----	----	----	----	----
21,000	----	----	----	----	9	49	−57.9	----	5	47	−57.8	----	10	48	−60.4	----	----	----	----	----	7	48	−59.6	----	----	----	----	----

[1] Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5-standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels also the humidity data is not used in daily observations when the temperature is below −40° C.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during October 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (302 m)		Billings, Mont. (1,095 m)		Boston, Mass. (15 m)		Brooklyn, N. Y. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	2	1.7	15	1.4	275	2.1	336	1.5	345	2.2	274	3.5	217	1.3	53	0.4	237	1.4	170	0.8	2	1.4	50	2.5	325	0.4
500	----	----	55	2.4	----	----	353	2.6	9	4.8	----	----	235	4.9	213	1.3	251	4.1	230	1.3	113	1.4	59	5.2	315	0.7
1,000	----	----	56	3.5	----	----	319	1.8	356	5.0	----	----	258	5.1	270	3.3	255	5.7	282	2.8	89	2.3	91	3.8	154	1.5
1,500	----	----	15	2.2	256	3.1	307	4.0	343	5.0	----	----	270	6.3	296	4.0	273	5.8	279	5.4	66	2.7	122	1.3	175	2.7
2,000	171	2.2	347	2.9	263	4.4	312	4.3	315	4.9	269	5.4	274	6.4	308	4.4	296	5.3	270	8.0	63	2.5	153	0.7	190	4.0
2,500	214	5.0	352	2.7	280	5.2	306	5.7	323	5.5	269	6.7	282	6.1	314	3.8	290	6.7	276	8.8	44	3.3	190	0.4	201	4.2
3,000	223	5.6	7	3.9	277	5.7	307	7.7	324	4.8	268	4.8	293	6.6	339	4.1	298	6.4	296	10.7	53	3.3	300	0.6	231	3.0
4,000	222	6.8	3	4.1	248	2.2	351	5.5	347	7.3	266	5.1	----	----	328	6.4	308	6.8	305	7.6	17	3.0	118	0.8	254	2.5
5,000	244	6.5	358	2.4	----	----	----	----	----	----	216	8.9	----	----	----	----	----	----	----	----	349	3.9	----	----	----	----

Altitude (meters) m. s. l.	Nashville, Tenn. (194 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla. [1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	224	0.4	158	1.0	167	2.9	166	1.1	47	2.5	34	4.0	247	0.8	162	3.5	25	0.8	98	1.0	145	1.3	154	0.6	320	1.1
500	166	2.1	235	1.3	179	5.2	205	4.3	71	5.4	65	5.7	217	3.5	----	----	330	1.7	185	1.4	175	3.0	----	----	346	3.6
1,000	278	1.6	278	1.3	199	8.0	240	8.3	80	5.7	55	4.7	267	3.4	----	----	316	1.8	271	4.2	194	5.0	188	1.3	350	4.0
1,500	312	2.8	270	2.7	218	4.7	245	8.4	83	4.4	43	4.5	278	4.6	166	5.5	278	1.0	277	6.3	205	5.2	226	1.8	333	5.3
2,000	334	4.0	244	1.8	243	3.4	261	7.9	85	4.1	30	4.4	283	4.8	183	5.2	202	2.2	283	8.9	202	4.5	233	1.9	324	5.5
2,500	336	4.0	246	2.1	264	3.0	272	6.8	76	2.4	41	3.8	287	5.6	205	4.4	195	3.0	302	7.3	195	5.3	229	3.0	318	5.5
3,000	337	3.4	251	1.8	280	2.7	282	7.0	73	2.0	7	2.7	290	6.4	216	4.2	207	2.9	303	8.0	----	----	221	3.2	310	6.2
4,000	353	4.3	305	2.8	319	3.6	299	6.5	26	2.3	316	4.9	302	4.1	210	5.2	189	4.8	----	----	----	----	250	3.5	341	7.5
5,000	18	4.0	332	4.0	----	----	----	----	9	3.6	----	----	----	----	274	3.8	214	7.6	----	----	----	----	199	3.2	----	----

[1] Navy stations.

TABLE 3.—*Maximum free air wind velocities (m. p. s.), for different sections of the United States, based on pilot balloon observations during October 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	39.2	SW	2,140	26	Cleveland, Ohio	30.0	SW	3,700	19	Cleveland, Ohio	39.0	WNW	9,880	15	Cleveland, Ohio.
East-Central [2]	30.2	WSW	2,230	26	Cincinnati, Ohio	31.0	W	3,490	26	Cincinnati, Ohio	50.0	SW	6,840	24	Greensboro, N. C.
Southeast [3]	28.2	WNW	2,500	27	Spartanburg, S. C	34.6	SW	5,000	24	Charleston, S. C	46.0	SW	6,960	24	Charleston, S. C.
North-Central [4]	29.1	NNE	1,000	14	Huron, S. Dak	41.8	NNW	4,930	26	Fargo, N. Dak	48.0	W	9,130	13	Fargo, N. Dak.
Central [5]	35.4	W	2,390	5	Evansville, Ind	36.8	NNW	3,330	27	Moline, Ill	54.0	WNW	11,930	25	Evansville, Ind.
South-Central [6]	29.2	S	1,530	17	Amarillo, Tex	26.6	NW	3,910	23	Oklahoma City, Okla.	45.0	W	12,330	21	Oklahoma City, Okla.
Northwest [7]	34.8	SE	820	28	Medford, Oreg	35.0	SSW	2,880	28	Pendleton, Oreg	59.2	NE	9,380	8	Billings, Mont.
West-Central [8]	35.2	S	2,100	14	Salt Lake City, Utah	34.4	SSW	3,000	15	Salt Lake City, Utah	78.0	SW	7,960	17	Denver, Colo.
Southwest [9]	27.6	SSW	2,500	15	Las Vegas, Nev	50.0	SSW	3,540	15	Las Vegas, Nev	59.2	WSW	14,040	18	Albuquerque, N. Mex.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

No floods occurred during the month of October 1938 with the exception of floods in the upper Mississippi Basin and in the lower Rio Grande which were a continuation of overflows that began in September. The flood in the upper Mississippi will be discussed below. The overflow in the Rio Grande was limited to the extreme lower reach of the river. Flood stage was exceeded at Mercedes and Brownsville, Tex., from September 29 to October 3 and crested on October 1 at a stage of 22.0 feet at the former station and 18.6 feet at the latter. The principal damage in this flood was caused by a break in the main levee, on the American side of the river, about 2 or 3 miles above Brownsville, Tex., resulting in inundation of approximately 1,200 acres of land. The total damage has been estimated at $2,500.

The upper Mississippi flood resulted from heavy rains over southern Minnesota, southern Wisconsin, northern Illinois, and central and northern Iowa. The flood was largely a tributary flood, with the Chippewa, Black, Wisconsin, Zumbro, and Whitewater Rivers particularly, experiencing unusually severe floods. The heavy rains began about September 5 and continued until September 14, and occurred again from the 17th to the 19th, but the rains of the latter period were not generally as intense and did not have a great effect on the high water except to prolong it somewhat. Figure 1 shows the distribution of precipitation from September 5 to 14. The data used in the preparation of the isohyets may be found in *Climatological Data*.

A meteorological analysis of the storm shows that the rainfall was caused primarily by a strong influx of moist tropical air from the south and southwest overrunning a wedge of cold polar air to the north and northeast over the extreme upper portion of the Mississippi Valley. This condition persisted almost entirely from September 5 to 14.

The front at the surface lay in a general east-west direction approximately over the southern boundaries of Minnesota and Wisconsin and remained almost stationary from the 5th to the 12th. A series of active waves moving along this front produced frequent rains during this period. On the 12th a mass of polar air moved in from the northewst and the front was displaced slightly to the southeast, resulting in clearing weather temporarily. However, on the morning of the 13th another wave had advanced northeastward to southwestern Iowa accompanied by moderately heavy precipitation. This disturbance moved slowly eastward from that point followed by a large mass of dry polar air which dominated the upper Mississippi region by the evening of September 14.

The stream of tropical air which invaded the upper Mississippi Valley from September 5 to 14 was maintained by a large anticyclone situated over extreme eastern United States and extending to high elevations. At 14,000 feet the center was located approximately over western Tennessee and dominated most of the eastern half of the country. The persistence of this anticyclone prevented any marked invasion of polar air except in the extreme upper portion of the Mississippi Basin until the 14th, when the anticyclone weakened considerably at high levels and was displaced to the southward and southeastward. At the same time a low at high levels moved eastward over the Lake region and brought in cold air from the northwest over most of the Mississippi Valley.

The flood was unusual in that floods rarely occur at that season of the year in the upper Mississippi Basin, the flood season extending usually from March to June. Table 1 presents crest stages at various points on the principal streams together with comparative data.

The following reports have been submitted by the officials in charge at the various river district offices in the upper Mississippi Valley:

LA CROSSE, WIS., RIVER DISTRICT

Whitewater and Zumbro Rivers in Minnesota.—An intense local flood of short duration occurred in the Whitewater River area from September 6th to 9th. Two storms of over 2 inches of rain produced disastrous floods in this valley which caused considerable loss to bridges, highways, crops, and a few buildings. Flood damage was greatest at Weaver, Minn., also considerable damage occurred at Elba and Beaver, Minn.; the latter town was isolated and had the highest stage recorded in years. Rains of great in-

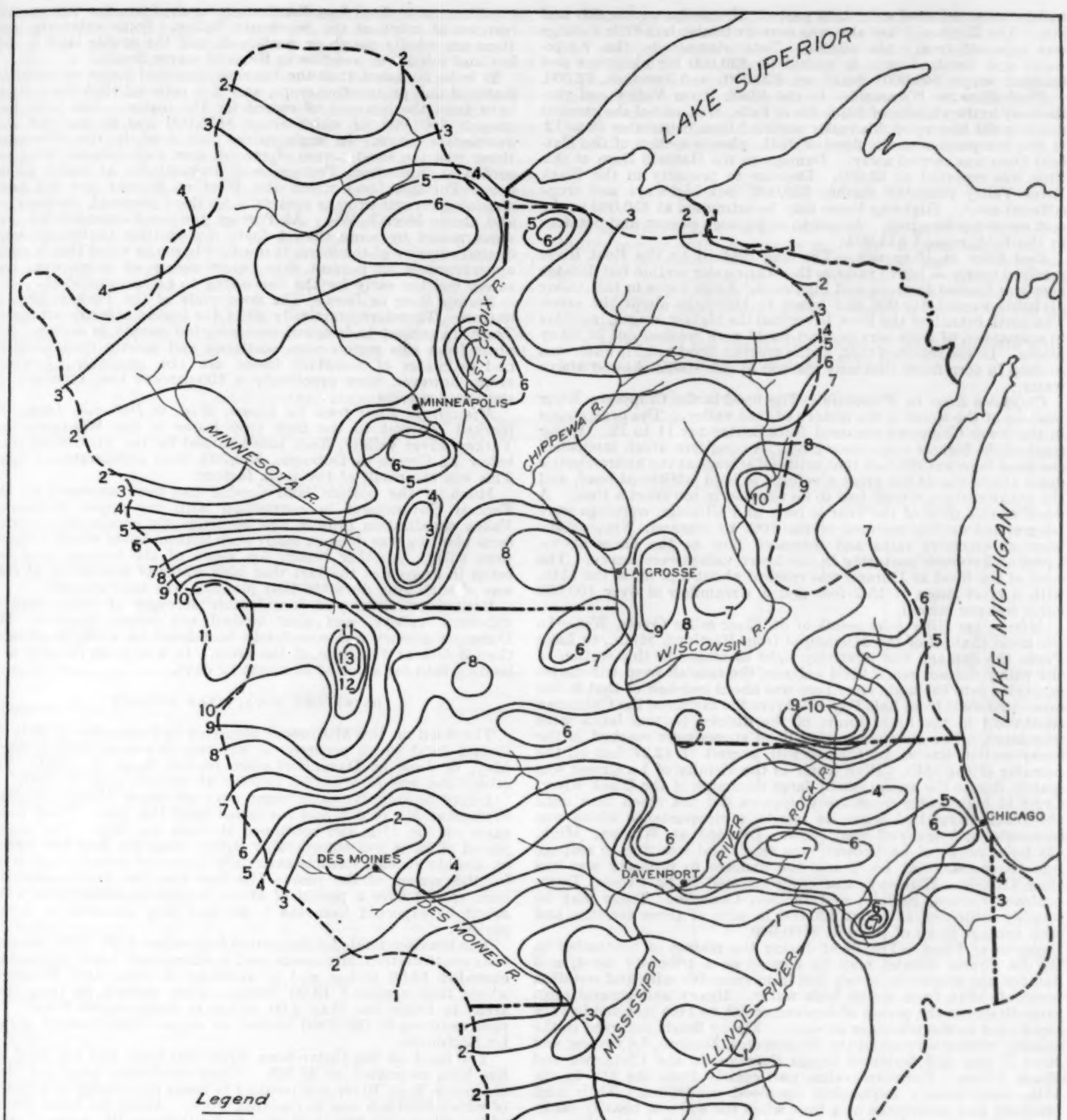

FIGURE 1.—Total precipitation over upper Mississippi Basin, September 5 to 14, 1938, inclusive.

tensity were centered over this part of Minnesota on the 6th and 8th. The Zumbro River also was over its banks, but little damage was reported from this section. Total damage to the Whitewater and Zumbro areas is placed at $30,000 for highways and bridges; crops, $40,000; buildings, $20,000; and livestock, $2,000.

Black River in Wisconsin.—In the Black River Valley and particularly in the vicinity of Black River Falls, Wis., one of the greatest floods in the history of this valley occurred from September 10 to 12. It was comparable to the flood of 1911, when a section of the Hatfield Dam was carried away. Damage to the Hatfield Dam at this time was reported as $2,000. Damage to property in the Black River Valley probably reaches $20,000, but highways and crops suffered most. Highway losses may be estimated at $30,000 as the cost necessary to repair. Losses to crops, such as corn and potatoes in the field, exceed $15,000.

Root River in Minnesota.—The area drained by the Root River received nearly as heavy rains as the Whitewater section but damage here was limited to crops and highways. Crop losses in this valley probably exceed $10,000 and losses to highways about the same. The north branch of the Root River had the highest stages, resulting in suspension of train service, and roads were washed out in many places. It was reported that, at the greatest flood height, water was so deep in corn fields that only the top of the stalks showed above water.

Chippewa River in Wisconsin.—The flood in the Chippewa River was one of the worst in the history of that valley. The peak stages in the lower Chippewa occurred from September 11 to 12. Water reached the highest stage since 1884. A condition which intensified the flood here was the fact that artificial storage at the hydro-electric dams above was at too great a volume to hold additional head, and the entire surface run-off had to be released in too short a time. A flood at this time of the year is rare, and although warnings were telegraphed on the morning of the 10th to Durand, Wis., on the basis of excessive rains and increased flow at the dams above, losses to livestock pasturing in the lower valley were heavy. The crest of the flood at Durand was reached about 3 p. m. of the 11th, with a crest stage of 15.2 feet and a streamflow of over 100,000 cubic feet per second.

Mississippi River from mouth of St. Croix to La Crosse, Wis.—In the main channel of the Mississippi from Hastings, Minn., to Lake Pepin the damage was relatively light as stages in this section of the valley did not reach flood volume; the rainfall from tributaries emptying into the main river here was about one-half of that in the area southward from Lale Pepin. From the mouth of the Chippewa southward to the lower limits of the district bottom lands were inundated. The only place were flood stages were reached in the lower section was at La Crosse, with a crest of 12.27 feet on the morning of the 15th. High water in the vicinity of La Crosse was mainly due to the exceptionally large discharge of the Black River. Crest of high water from the Chippewa did not reach here until the Black River had begun to recede, a circumstance which was fortunate and lessened peak flow. Damage at Winona, Minn. (28 miles north of La Crosse), was small and was due to seepage into basements. At La Crosse the damage to property was less than $10,000. Highways and crops suffered in La Crosse, Trempealeau, Vernon, Buffalo, and Jackson Counties. These may be roughly estimated at about $20,000 in each of those counties and crop damage in all of them at $100,000.

Source of Flood.—The flood during the middle of September in the La Crosse district may be classed as a tributary flood, and damage was greater in money loss from excessive rains and resulting washouts than from actual high water. Heavy and general rains extending over the period of September 5th to 14th resulted in very rapid rises in the tributary streams. Flashy floods occurred in the smaller tributaries such as the Whitewater, Zumbro, La Crosse, and Root Rivers and floods of longer duration in the Chippewa and Black Rivers. Excessive rains, particularly from the 6th to the 11th, were mainly responsible for flood conditions. Their high intensity and occurrence at a time when the soil was heavily saturated with moisture from abnormally heavy rainfall during the summer resulted in a large percentage of run-off. There was a definite concentration of rainfall of over 8 inches, in the period September 5th to 14th, over the area of the Root River drainage and extending north to the Whitewater Valley and in Wisconsin, in La Crosse, and Trempealeau Counties. Another marked area of heavy rainfall appears over the Chippewa Basin and centered over the Red Cedar River drainage, and another in the Black River Basin. These rains resulted in a rapidly forming flood, the intensity of which was greatest in the tributary streams. Stages in these tributaries, especially in the Chippewa, were the highest recorded for many years.

DUBUQUE, IOWA, RIVER DISTRICT

Wisconsin River.—Review of the individual reports received from various points along the Wisconsin River shows that losses were most severe at scattered points in the middle reaches. This erratic condition as to flood loss distribution results from the topographic features of much of the Wisconsin Valley. Some extensive portions are wholly marsh or wasteland, and the arable land is also low and subject to overflow in times of severe floods.

It is to be noted that the heaviest classified losses occurred in matured and prospective crops, and it is believed that these losses have been the heaviest of record for the region. The total loss exceeds $900,000, of which about $675,000 was to matured and prospective crops. In explanation, this flood in the Wisconsin River was the most severe of record, new high records being recorded at Knowlton, Portage, and undoubtedly at many points below Portage, from which the Weather Bureau has not been obtaining reports or gage records. No flood occurred, however, at and above Merrill, Wis. At Portage the crest exceeded the previous record by more than 1 foot. In addition to the unprecedented severity of the flood, it must be borne in mind that it came approximately at harvest time, when nearly all crops were matured, but too early for the harvesting to be accomplished.

Turkey River in Iowa.—The flood plain of the Turkey River is narrow. Therefore practically all of the lowlands farms are small. They are subject to frequent overflow, but mostly in spring. Reports from this region were scattered and mostly unsatisfactory and estimates of monetary losses are not available. Lowland crops, however, were practically a 100-percent loss, especially in the lower reaches.

Mississippi River from La Crosse, Wis., to Dubuque, Iowa.—In marked contrast to the high crop losses in the Wisconsin and Turkey River valleys, flood losses caused by the Mississippi from below La Crosse to Dubuque, $30,700, were comparatively light. This was the result of two main factors:

Much of the bottom land flooded has been acquired by the Federal Government in connection with the upper Mississippi Valley canalization project, and consequently comparatively little farm planting was done on many such bottom lands which formerly were tilled. Another reason for much of the bottom land not being in crops was the fact that high water of the spring of 1938 was of such long duration that planting was impracticable.

Backwaters destroyed considerable acreages of sweet corn in tributary valleys, and also washed out island gardens. The Dubuque airport was completely inundated to a depth of more than 3 feet at the time of the crest. It was unserviceable as a landing field for a period of about 12 days.

DAVENPORT, IOWA, RIVER DISTRICT

The flood on the Mississippi occurring in September 1938 is the second flood which occurred in any month except March, April, May, or June at Davenport since records began in 1860. The other flood was recorded on October 13 to November 3, 1881.

Heavy to excessive rains began over the upper Mississippi Basin September 5th or 6th and continued until the 14th. They began again on the 17th and continued through the 19th. The second period of rains was considerably lighter than the first but coming on already swollen streams materially increased already high crests for this season of the year. The fact that the first heavy rains were spread over a period of about 9 days lessened crests which might be expected from the totals had they occurred in shorter periods.

The heaviest totals for the period September 1–20, 1938, occurred over southwestern Minnesota and northwestern Iowa, where they exceeded 10.00 inches and in portions of Iowa and Wisconsin, where they exceeded 13.00 inches. They shaded off from these areas to totals less than 2.00 inches in southeastern Iowa. The rises resulting in the flood started on stages slightly above normal for September.

The flood on the Cedar-Iowa River was local and the total loss has been estimated at $3,500. Flood conditions prevailed along the entire Rock River and resulted in losses amounting to $230,000, of which $200,000 was to matured crops. Along the main channel of the Mississippi from Dubuque to Keithsburg, Ill., a loss of about $121,000 was reported.

DES MOINES, IOWA, RIVER DISTRICT

Des Moines River.—Rarely, if ever, have heavy rains in the upper drainage basin of the Des Moines River above Fort Dodge, Iowa, produced enough volume of water to cause overflow on the lower lands down nearly to Ottumwa, Iowa, and never had this occurred in September until 1938. The flat topography of the upper drainage basin is not conducive to rapid run-off and as a rule the rains, however heavy, accumulate to form ponds of large total area in which the water slowly settles into the ground.

During August, rains in that area had been light, but the total rainfall of April, May, June, and July had been considerably above normal. In 3 days, September 5th–8th, 4 to 7 inches of rain occurred with only moderate run-off, but this had scarcely settled

from the surface, or run into the streams, till there was another 4-day period with rains of 4 to 6 inches, most of which came on the 12th and 14th. Fortunately, no important rains occurred in either of these periods below Boone, Iowa, on the Des Moines River, or below Jefferson, Iowa, on the Raccoon River. If the same rainfall had occurred in the lower Raccoon and middle Des Moines valleys serious floods would probably have followed.

The highest stage at Boone was 23.1 feet at 3:55 p. m., September 18. This is 3.1 feet above flood stage and has seldom been exceeded. The highest water of record, May 1903, would have read 26.9 on the present gage and the high water of June 5, 1918, would have read 24.1 on this gage. The lowest lands were flooded from Boone nearly to Ottumwa. At Des Moines the highest stage was 14.7 feet at 3 p. m., September 20. This is the highest September stage of record, but 2.3 feet below the flood stage along the city front. However, there was much overflow just above and below the city, particularly at Sycamore Park and Waukonsa Beach where some of the residents were obliged to move. At Tracy, the highest stage was 14.95 feet, 3 p. m., of the 23d, to 7 a. m., of the 24th, about 1 foot higher than flood stage. At Eddyville the highest stage was 15.8 feet at 7 a. m. of the 24th, and there was considerable overflow on the west bank. At Ottumwa the highest stage was nearly 9 feet, not quite bankful.

There was no very high water in the Raccoon River below Perry, Iowa. The highest stage reached at Van Meter, Iowa, was 10.7 feet about midnight of the 14th and there was another slight crest of 9.9 feet at 7 a. m. of the 21st, flood stage 13 feet.

Damage was mostly to corn, matured but not yet harvested, however there was some damage to other crops and to fences, roads, bridges, and buildings. The total damage along the Des Moines River and its tributaries from the headwaters to Ottumwa was $72,852, while the total amount saved by warnings was $16,600.

KEOKUK, IOWA, RIVER DISTRICT

Mississippi River from Keithsburg, Ill., to Louisiana, Mo.—Stages in this portion of the river were at, or above flood stage, from 10 to 16 days, however, losses were comparatively light, totaling about $12,500. Inasmuch as the flood originated some distance upstream it was possible to issue warnings considerably in advance and precautions were taken which probably were responsible for the slight damage.

A report on the September flood in New England will be presented in a later issue of the REVIEW.

TABLE 1.—*Crest stages along upper Mississippi River and tributaries and comparative data*

[All dates in September unless otherwise specified]

Station and river	Flood stage	Above flood stages—dates: From—	Above flood stages—dates: To—	Crest: Stage	Crest: Date	Previous September record: Stage	Previous September record: Year
Minnesota River	*Feet*			*Feet*		*Feet*	
Mankato, Minn.	19			15.7	7 a. m., 19	11.4	1906
Chippewa River							
Durand, Wis.	11			15.2	3 p. m., 11		
Zumbro River							
Theilman, Minn.				38.5	11		
Whitewater River							
Beaver, Minn.				92.0	10		
Black River							
Galesville, Wis.	10	10	15	13.7	12		
Wisconsin River							
Merrill, Wis.	11			9.6	10	10.3	1928
Knowlton, Wis.	12	9	13	19.9	2-4 a. m., 11	[1] 16.9	1928
Wisconsin Rapids, Wis.	[2] 12	11	12	13.35	6 p. m., 11 / 5 a. m., 12	11.3	1912
Wisconsin Dells, Wis.	16	13	16	18.8	14		
Portage, Wis.	17	13	18	20.5	4 p. m., 14	[3] 18.1	1928
Rock River							
Moline Bridge, Ill.	10	9	Oct. 5	11.9	18, 20, 22–26	9.0	1931
Cedar River							
Janesville, Iowa				7.9	16		
Cedar Rapids, Iowa	13			6.9	21	9.1	1915
Iowa River							
Wapello, Iowa	10			5.8	7 a. m., 24	11.8	1926
Skunk River							
Augusta, Iowa	15			4.2	17	19.9	1926
Raccoon River							
Van Meter, Iowa	13			10.7	15	18.8	1926
Des Moines River							
Boone, Iowa	20	16	20	23.1	4 p. m., 18	[4] 8.6	1926
Des Moines, Iowa	17			14.7	3 p. m., 20	13.2	1926
Tracy, Iowa	14			14.95	3 p. m., 23 / 7 a. m., 24		
Ottumwa, Iowa	9	25	25	9.0	7 a. m., 25	12.3	1926
Keosauqua, Iowa	20			9.0	25		
Mississippi River							
Fort Ripley, Minn.	10			5.2	14	6.8	1928
Minneapolis, Minn.	16			7.1	15		
St. Paul, Minn.	14			4.5	24	11.9	1903
Hastings, Minn.	18			6.8	16		
Red Wing, Minn.	14			9.5	14	11.9	1903
Reads, Minn.	12			9.7	14	11.0	1903
Winona, Minn.	13			11.8	15	8.1	1926
La Crosse, Wis.	12	13	16	12.3	7 a. m., 15	13.3	1903
Prairie du Chien, Wis.	18	18	20	18.4	1 p. m., 18	16.7	1903
Dubuque, Iowa	18	18	25	20.5	Noon, 20	17.4	1903
Clinton, Iowa	16	19	28	18.3	22–23	11.1	1928
La Claire, Iowa	10	19	28	11.6	23	10.8	1903
Davenport, Iowa	15	21	27	15.8	24	13.7	1903
Muscatine, Iowa	15	20	Oct. 1	18.5	24	13.9	1903
Keithsburg, Ill.	12	20	do.	14.3	25		
Keokuk, Iowa	12	21	Oct. 3	16.4	Noon, 26	13.4	1926
Quincy, Ill.	14	21	Oct. 4	18.3	27	14.8	1926
Hannibal, Mo.	13	20	Oct. 6	18.1	8 a. m., 27	14.9	1926
Louisiana, Mo.	12	21	Oct. 5	16.3	28	14.0	1926

[1] Highest stage previously recorded was 19.5 feet, April 1922.
[2] Warning stage.
[3] Highest stage previously recorded was 19.2 feet, October 1911.
[4] Record incomplete.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, OCTOBER 1938

By H. C. HUNTER

Atmospheric pressure.—The pressure averaged decidedly less than normal over the north-central and northeastern portions of the North Atlantic. At Reykjavik, Iceland, the monthly average was almost half an inch below normal, and even the highest reading reported there was slightly below the month's normal. The southeastern North Atlantic had pressures moderately above the normal, the departure at Horta, in the Azores, being +0.13 inch, and the lowest reading being but a trifle below the month's normal. Near the Maritime Provinces, Newfoundland, and southern Labrador, the pressure averaged slightly more than normal, and near Bermuda and the central West Indies slightly less.

During the first week and for most of the period after the 20th both the Icelandic LOW and the Azores HIGH were much more intense than usual.

The extremes of pressure found in vessel reports at hand are 30.61 and 28.33 inches. The higher mark was noted on the Norwegian motorship *Europe*, during the forenoon of the 3d, when the vessel was near 38° north latitude, 36° west longitude, or slightly to westward of the westernmost Azores. The low reading was recorded on the American liner *American Shipper*, also on the 3d, but early in the afternoon, at about 55° N., 15° W. There was a slightly lower reading at the Reykjavik station on the 24th, as table 1 shows.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, October 1938.*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.49	−0.25	29.96	15	28.82	26
Reykjavik, Iceland	29.21	−.47	29.65	11	28.32	24
Lerwick, Shetland Islands	29.48	−.31	30.03	20	28.38	4
Valencia, Ireland	29.85	−.06	30.21	27	29.06	3
Lisbon, Portugal	30.12	+.10	30.28	4	29.71	24
Madeira	30.08	+.09	30.27	2	29.80	24
Horta, Azores	30.24	+.13	30.44	22	30.10	16
Belle Isle, Newfoundland	29.90	+.04	30.40	31	29.02	25
Halifax, Nova Scotia	30.06	+.02	30.50	3	29.28	25
Nantucket	30.05	.00	30.40	23	29.33	24
Hatteras	30.06	.00	30.39	11	29.53	24
Bermuda	29.99	−.08	30.24	12	29.72	28
Turks Island	29.92	−.03	30.03	23	29.77	28
Key West	29.94	.00	30.14	9	29.70	14
New Orleans	30.06	+.03	30.28	9	29.90	23

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—During the first days of October there was a weak cyclone not far to eastward of the coast of the South Atlantic States; it moved generally in a northeasterly direction and about the 5th merged with the southern part of a far-northern, low-pressure area. Much more important on these days was the vast system of low pressure affecting the northeastern part of the ocean, an especially intense LOW being near Iceland and the British Isles on the 3d and 4th. Along the chief steamship routes to northwestern Europe at this time many vessels met strong gales to northward of the 45th parallel and to eastward of mid-ocean; and two liners not far to the westward of Ireland—the *American Shipper* and the German *Berlin*—each of them, when north of the 52d parallel, encountered force-12 winds—the only instances found in the month's reports from the Atlantic.

A cyclone of no great strength when near Bermuda on the 7th and 8th developed very rapidly as it traveled northeastward on the 9th and 10th, being near Newfoundland during the intervening night. Strong to whole gales were reported by many vessels. Chart IX presents the situation on the 9th. This storm continued northeastward so that by the 13th it was too far to northward to affect vessels on the main shipping lanes.

A LOW that crossed the Gulf of St. Lawrence, moving eastward, on the 17th, became quite intense by the 19th, when centered near 55° N., 30° W., and one vessel near mid-ocean, close to the 48th parallel, met force-11 winds, the only instance after the 6th of the month of a force exceeding 10 in the Atlantic. By the 20th the LOW was centered far to the northward, with decreased energy.

Cyclones of low latitudes.—Elsewhere in this issue is an account of three disturbances that affected lower North Atlantic latitudes during the second and the first half of the third decades. Chart X shows the tracks of these LOW areas, the first and second taking quite unusual paths, generally with small progressive motion. Except the third LOW, after it had moved to northward of the 33d parallel, none of these storms attained more than moderate intensity.

The first disturbance originated near Tela, Honduras, spent 4 days or more over the eastern Gulf of Mexico, then turned northwestward to cross the Texas coast on the 17th. The table of ocean gales and storms presents some reports connected with this LOW, none of them showing wind force exceeding 8.

The second disturbance, noted first near Bermuda, was not far from the east Florida coast on the 19th and 20th, then turned northeastward to merge with a northern LOW.

The third disturbance was central not far from Tampico on the evening of the 22d. Traveling rapidly over western, central, and northeastern parts of the Gulf of Mexico, then across northern Florida, it was near the South Carolina coast early on the 24th. It then advanced northeastward near the coast line and merged with a LOW to the northward, reaching the Gulf of St. Lawrence with a marked increase in strength by the following morning.

Fog.—The usual decrease in fogginess from September is indicated by October reports at hand. Save near the United States coast, approximately from Cape Cod to Cape Hatteras, and over a small part of the Grand Banks area, there was less fog than during September.

To southeastward of New England and Nova Scotia there was distinctly less fog than past October averages indicate, while to eastward of New Jersey and Delaware Bay there was more, but all of it was noted after the 13th. The 5° square, 35° to 40° N., 70° to 75° W., had fog on 9 days, while the maximum fogginess reported in the North Atlantic was in the 5° square from 40° to 45° N., 45° to 50° W., with 10 days.

OCEAN GALES AND STORMS, OCTOBER 1938

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began October—	Time of lowest barometer, October—	Gale ended October—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Collamer, Am. S. S.	Havre	New York	43 05 N.	61 45 W.	1	6a, 1	1	29.57	ESE	SSW, 7	NW	SSE, 8	SSE-SW.
Cordelia, Br. M. S.	Halifax	Houston	34 20 N.	71 01 W.	2	8a, 2	2	29.78	N	N, 8	NNW	N, 9	N-NNW.
American Merchant, Am. S. S.	London	New York	49 48 N.	7 13 W.	2	10a, 2	2	29.79	WNW	WNW, 6	WNW	WNW, 8	None.
Maravi, Pan. S. S.	Preston, Cuba	Boston	34 24 N.	71 24 W.	2	1a, 3	3	29.58	E	N, 9	N	N, 9	NW-N.
President Harding, Am. S. S.	New York	Cobh	49 55 N.	32 24 W.	2	4a, 3	4	29.65	W	W, 8	W	NW, 9	W-NW.
Washington, Am. S. S.	Cobh	New York	50 54 N.	19 36 W.	3	8a, 3	4	29.38	W	W, 8	WNW	W, 10	WNW-W.
Berlin, Ger. S. S.	Galway	Halifax	53 01 N.	9 31 W.	2	10a, 3	5	28.86	WNW	WSW, 12	WNW	W, 12	WSW-WNW.
Statendam, Du. S. S.	Rotterdam	New York	50 47 N.	16 52 W.	3	Noon, 3	5	29.20	W	W, 8	WNW	WNW, 10	SW-W.
American Shipper, Am. S. S.	Belfast	Boston	55 26 N.	15 15 W.	3	2p, 3	5	28.33	S	WNW, 8	W	WNW, 12	SSW-WNW.
Binnendijk, Du. S. S.	Three Rivers	Rotterdam	[1]50 20 N.	2 28 W.	3	6p, 3	4	29.09	S	S, 9	WSW	S, 9	S-WSW.
Scanmail, Am. S. S.	Copenhagen	New York	[1]57 14 N.	23 52 W.	4	2p, 4	5	29.04	W	W, 8	WNW	WNW, 9	W-NW.
Do.	do.	do.	[1]56 09 N.	29 03 W.	5	4a, 6	7	29.07	WSW	W, 8	NW	WNW, 10	WSW-WNW.
Sunbeam, Am. S. S.	Montreal	Corpus Christi	37 50 N.	68 05 W.	7	2p, 8	9	29.66	NE	N, 7	NW	NNW, 8	E-NNW.
Warrior, Am. S. S.	Mobile	London	39 40 N.	60 03 W.	9	8a, 9	10	29.20	SW	SW, 7	NW	W, 10	SSW-W.
Executive, Am. S. S.	Gibraltar	New York	36 05 N.	57 20 W.	8	9a, 9	10	29.76	SE	SW, 9	NW	SW, 9	SW-W.
Excambion, Am. S. S.	do.	Boston	43 12 N.	53 48 W.	9	11p, 9	10	29.10	S	SW, 10	NW	SW, 10	S-W.
American Shipper, Am. S. S.	Belfast	do.	46 00 N.	54 24 W.	10	2a, 10	10	28.82	W	SSW, 5	NW	NW, 10	ESE-SSW-WNW.
Pipestone County, Am. S. S.	Bordeaux	New York	44 24 N.	46 06 W.	10	9a, 10	11	29.47	W	SW, 7	WNW	W, 10	SE-SW-W.
Darien, Pan. S. S.	Puerto Cortez	Boston	18 30 N.	86 48 W.	11	6p, 10	11	29.82	E	E, 5	E	ESE, 6	ENE-ESE.
New York, Ger. S. S.	Cobh	New York	49 36 N.	38 36 W.	11	9a, 11	11	28.82	SW	SW, 9	W	W, 9	SSW-W.
Sinaloa, Hond. S. S.	New Orleans	Tela	19 54 N.	86 48 W.	11	Noon, 11	11	29.80	SSE	SE, 6	SE	SE, 6	SE-S.
Nieuw Amsterdam, Du. S. S.	Rotterdam	New York	49 28 N.	33 40 W.	11	1p, 11	12	29.28	SW	SW, 10	WSW	SW, 10	None.
Carrillo, Am. S. S.	Havana	Puerto Barrios	19 36 N.	86 00 W.	11	3p, 11	11	29.82	ESE	SE, 5	SE	ESE, 7	
El Isleo, Am. S. S.	Norfolk	Houston	26 00 N.	87 37 W.	13	7a, 13	13	29.67	SE	NNE, 8	NNE	NNE, 8	SE-NNE.
Shenandoah, Am. S. S.	Providence	Port Arthur	25 55 N.	85 36 W.	13	1p, 13	14	29.75	SW	NNE, 8	NE	NE, 8	S-N-NE.
Allan Jackson, Am. S. S.	Jacksonville	Texas City	25 53 N.	87 10 W.	13	2p, 13	13	29.69	NE	NE, 7	NE	NE, 8	None.
Sunbeam, Am. S. S.	Montreal	Corpus Christi	26 01 N.	86 04 W.	13	6p, 13	14	29.67	E	E, 8	NNE	NNE, 8	E-NNE.
Contessa, Hond. S. S.	New Orleans	Havana	25 14 N.	84 40 W.	12	2a, 14	14	29.61	ESE	S, 6	S	NE, 8	NE-S-SSW.
American Merchant, Am. S. S.	New York	Plymouth	43 20 N.	46 30 W.	18	4p, 18	20	29.58	NW	NW, 6	W	W, 8	None.
President Harding, Am. S. S.	Cobh	New York	46 25 N.	41 35 W.	18	8p, 18	19	29.17	SSW	NNW, 8	NW	NNW, 9	SSW-NNW.
American Banker, Am. S. S.	London	do.	48 14 N.	31 54 W.	18	3a, 19	19	28.99	S	S, 11	WNW	S, 11	S-W.
Aalsum, Du. S. S.	Wabana	Rotterdam	51 20 N.	31 50 W.	18	5a, 19	19	[2]28.76	S	SSW, 9	SW	SSW, 9	S-SW.
Omphale, Fr. S. S.	Corpus Christi	St. Nazaire	[1]47 26 N.	20 20 W.	15	2a, 20	20	29.55	SSW	NW, 6	NW	SSW, 10	SSW-NW.
American Merchant Am. S. S.	New York	Plymouth	48 42 N.	25 00 W.	22	10a, 21	22	29.55	NW	SW, 6	NW	NW, 8	SSE-W.
Metapan, Am. S. S.	Tela	Boston	34 12 N.	75 36 W.	21	1p, 21	21	29.58		N, 8	N	N, 8	NW-N.
American Banker, Am. S. S.	London	New York	43 10 N.	52 00 W.	21	9a, 22	22	29.57	WSW	S, 10	NW	S, 10	S-SW.
Stakesby, Br. S. S.	Montreal	Leith	58 47 N.	22 30 W.	23	4p, 23	24	[2]28.85	SW	SW, 6	W	W, 10	S-W.
Bertha Brovig, Nor. S S.	Progreso	New Orleans	25 55 N.	89 36 W.	23	5p, 23	23	29.75	NNW	NNW, 8	N	NNW, 8	SSW-NNW.
R. G. Stewart, Am. S. S.	Baton Rouge	Baltimore	34 36 N.	75 42 W.	23	4p, 24	24	29.53	ESE	WSW, 7	NW	S, 8	S-NNW.
Weltevreden, Du. M. S.	Sabang	New York	36 11 N.	67 54 W.	28	4a, 28	29	29.59	NE	S, 5	NE	NE, 8	
Cities Service Koolmotor, Am. S. S.	Port Arthur	Boston	32 30 N.	76 45 W.	29	4a, 29	31	29.62	NW	NW, 4	N	NW, 8	
NORTH PACIFIC OCEAN													
Michigan, Am. S. S.	Katangli, Sakhalin Is.	Portland, Ore.	48 45 N.	178 11 W.	2	6p, 1	2	29.40	W	E, 3	W	W, 8	ESE-NNE.
Mahimahi, Am. S. S.	Los Angeles	Balboa	15 54 N.	95 20 W.	3	3p, 3	4	29.75	SE	NE, 4	NNW	N, 7	SE-N.
Michigan, Am. S. S.	Katangli, Sakhalin Is.	Portland, Ore.	47 10 N.	161 56 W.	4	6p, 4	6	28.60	E	SSW, 11	WSW	SSW, 11	E-WSW.
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	51 51 N.	161 44 W.	4	6a, 5	5	28.07	SE	S, 10	NW	S, 11	SSE-W.
Hikawa Maru, Jap. M. S.	Vancouver, B. C.	do.	51 30 N.	158 45 W.	5	3p, 5	5	28.62	S	SSW, 9	W	S, 9	S-SW.
Skjelbred, Nor. M. S.	Yokohama	San Francisco	[1]42 33 N.	160 13 E.	4	8p, 5	6	29.14	ESE	ENE, 9	N	ENE, 9	E-NNE.
Tai Yin, Nor. M. S.	do.	Los Angeles	[1]45 08 N.	168 29 E.	5	6a, 6	6	29.16	ESE	E, 10	ENE	E, 10	E-NE.
Daisan Ogura Maru, Jap. S. S.	do.	San Francisco	39 56 N.	171 55 E.	5	Noon, 6	7	29.18	SE	WSW, 10	NW	WSW, 10	SW-W.
Michigan, Am. S. S.	Katangli, Sakhalin Is.	Portland, Ore.	47 13 N.	147 51 W.	7	Noon, 7	7	29.40	S	SW, 7	W	S, 8	S-WNW.
Barrgrove, Br. S. S.	Campha	Keelung	20 05 N.	113 15 E.	7	4p, 7	8	29.44	NE	E, 8	SE	E, 8	NE-ESE.
Lewis Luckenbach, Am. S. S.	Balboa	Los Angeles	[1]14 50 N.	94 42 W.	7	4a, 8	8	29.86	NW	NW, 7	NE	NW, 7	NW-NE.
Tai Yin, Nor. M. S.	Yokohama	do.	[1]47 08 N.	167 21 W.	8	4p, 8	8	29.64	SSW	WSW, 8	WSW	SW, 9	SW-WSW.
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	49 08 N.	177 46 E.	8	Mdt, 8	9	29.21	SSE	WSW, 9	NW	WSW, 9	SW-NW.
Ensley City, Am. S. S.	Honolulu	Balboa	18 55 N.	123 40 W.	9	4p, 9	9	29.43	NE	WNW, 8	WNW	WNW, 8	N-SSW.
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	42 40 N.	152 32 E.	10	6a, 11	11	29.57	SSE	S, 9	NW	S, 9	S-WSW.
Sanyo Maru, Jap. M. S.	Yokohama	Los Angeles	42 15 N.	158 10 E.	11	3p, 11	11	29.71	S	S, 9	S	S, 9	
Kaijo Maru, Jap. M. S.	do.	do.	45 10 N.	168 23 E.	12	11a, 12	12	29.74	SSE	SSE, 7	SSE	SSE, 8	
Heian Maru, Jap. M. S.	do.	Seattle	[1]50 14 N.	166 10 W.	13	8p, 13	13	29.44	S	SSE, 7	W	SSE, 8	SSE-W.
Ixion, Br. S. S.	do.	Vancouver	50 02 N.	147 17 W.	14	Mdt, 14	15	29.70	S	S, 8	S	S, 8	None.
Barrgrove, Br. S. S.	Keelung	Osaka	29 40 N.	130 40 E.	14	2a, 15	15	29.55	SSE	SW, 8	N	S, 8	SSE-SW.
Columbian, Am. S. S.	Los Angeles	Balboa	14 00 N.	93 12 W.	15	6p, 15	15	29.81	NE	NW, 3	NNW	N, 9	N-NW.
Kaijo Maru, Jap. M. S.	Yokohama	Los Angeles	46 15 N.	159 22 W.	15	2a, 16	16	28.83	S	SSW-10	WSW	SSW, 10	S-SW.
Sanyo Maru, Jap. M. S.	do.	do.	46 10 N.	158 42 W.	15	2a, 16	16	29.02	S	SW, 10	WSW	SW, 10	SSW-WSW.
Dagmar Salen, Swed. M. S.	Manila	do.	26 00 N.	144 30 E.	15	6a, 16	16	29.09	NNE	N, 8	SW	N, 8	N-W.
Silverguava, Br. M. S.	do.	Portland, Ore.	51 00 N.	155 00 W.	15	1p, 16	17	28.21	SE	S, 8	S	SE, 10	SSE-S.
Gefion, Nor. M. S.	Los Angeles	Yokohama	34 18 N.	143 18 E.	16	10p, 16	17	29.73		NE, 9		NE, 9	
Teiyo Maru, Jap. M. S.	Sasebo	Los Angeles	35 30 N.	149 00 E.	16	Mdt, 16	17	29.33	ENE	N, 8	N	NNE, 8	NE-N.
Empress of Japan, Br. S. S.	Victoria, B. C.	Honolulu	33 12 N.	146 48 W.	17	2p, 17	17	29.64		SW, 8		SW, 8	SW-WNW.
San Diego Maru, Jap. S. S.	Yokohama	San Francisco	41 40 N.	163 35 E.	17	3p, 17	18	28.84	S	SSW, 11	W	SW, 12	S-SW.
Roseville, Nor. M. S.	Hong Kong	Los Angeles	39 00 N.	138 36 W.	17	3p, 17	17	29.80	S	S, 8	S	S, 8	

[1] Position approximate.

[2] Barometer uncorrected.

OCEAN GALES AND STORMS, OCTOBER 1938—Continued

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began October—	Time of lowest barometer, October—	Gale ended October—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH PACIFIC OCEAN—Continued			° ′	° ′				Inches					
Leme, Ital, M. S.	Los Angeles	Balboa	13 18 N.	89 30 W.	17	6a, 18	17	29.88		ESE, 3		NNE, 8	
Toa Maru, Jap. M. S.	Kobe	San Francisco	42 36 N.	163 50 W.	17	2p, 18	18	29.09	W	W, 9	WNW	W, 9	
Kunikawa Maru, Jap. M. S.	Yokohama	do	45 57 N.	171 53 E.	17	Mdt, 17	20	28.80	ESE	SW, 11	N	NW, 12	ESE-SW-W.
Cingalese Prince, Br. M. S.	San Francisco.	Manila	20 39 N.	139 16 E.	18	4p, 19	20	29.61	S	S, 7	WSW	S, 7	None.
Empress of Canada, Br. S. S.	Yokohama	Honolulu	34 49 N.	140 58 E.	21	11a, 21	21	28.60	N	S, 12	NW	S, 12	SSE-SW.
Kunikawa Maru, Jap. M. S.	do	San Francisco	45 00 N.	143 34 W.	21	8a, 22	23	28.16	ENE	SSE, 10	WSW	WSW, 12	ESE-SSE-W.
Teiyo Maru, Jap. M. S.	Sasebo	Los Angeles	43 03 N.	174 42 W.	21	6a, 22	23	28.81	SW	W, 9	WNW	W, 9	SW-W.
Dagmar Salen, Swed. M. S.	Manila	do	[1] 39 33 N.	174 57 W.	22	6a, 22	22	29.32	W	W, 8	SW	W, 8	W-WSW.
Nozima Maru, Jap. M. S.	Balboa	do	17 24 N.	102 11 W.	22	8a, 22	22	29.64	SE	SW, 9	WSW	NW, 10	SW-NW.
Asuka Maru, Jap. M. S.	do	do	17 44 N.	102 25 W.	22	8a, 22	22	29.31	SSE	NNW, 9	W	NW, 11	S-NW-W.
San Diego Maru, Jap. S. S.	Yokohama	San Francisco	42 09 N.	164 30 W.	22	2p, 22	23	29.00	WSW	W, 8	WNW	W, 10	WSW-NW.
Swiftsure Bank Lightship, U. S. Lighthouse Service.	On station off Tatoosh Island, Wash.		48 30 N.	125 00 W.	26	6a, 26	26	29.57	SE	SE, 8	SSE	SE, 8	None.
Dagmar Salen, Swed. M. S.	Manila	Los Angeles	38 34 N.	140 38 W.	26	Noon, 27	27	29.29	S	WSW, 7	W	SSW, 11	SSW-W.
Amagisan Maru, Jap. M. S.	Yokohama	do	41 32 N.	150 22 W.	25	6p, 26	28	28.94	SW	SW, 7	WNW	NW, 10	SW-W.
Susan V. Luckenbach, Am. S. S.	San Francisco	Balboa	12 33 N.	90 24 W.	29	6a, 30	29	29.77		Calm	NNW	NNW, 7	
Nitro, U. S. Navy	do	Bremerton	41 56 N.	124 46 W.	30	6a, 30	30	[1] 29.76	SE	S, 6	SE	SE, 8	SE-S-NNW.

NORTH PACIFIC OCEAN, OCTOBER 1938

By WILLIS E. HURD

Atmospheric pressure.—Pressure conditions over the North Pacific Ocean during October 1938 were typically those of winter, with a strong Aleutian LOW and a well developed central Pacific HIGH. The lowest average pressure, among the Alaskan Islands, was 29.33 inches, at Kodiak. This was 0.26 inch below the normal of the month. Abnormally low pressures occurred throughout the Aleutian region, with minus departures decreasing in value southward along the American coast to −0.01 inch at San Francisco. The lowest pressure reported at a northern island station was 28.30 inches, at Kodiak, on the 23d. The lowest barometer reported by a ship was 28.07 inches, read on the British steamer *Empress of Russia*, in latitude 51°51′ N., longitude 161°44′ W., on the 5th.

The North Pacific anticyclone was centered in the vicinity of Midway Island. The average pressure at Midway was 30.15 inches, which is 0.12 inch above the normal of October.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, October, 1938, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Point Barrow	29.71	−0.22	30.16	31	29.22	18
Dutch Harbor	29.41	−.24	30.12	12	28.74	16
St. Paul	29.48	−.15	30.18	31	29.10	15
Kodiak	29.33	−.26	30.14	1	28.30	23
Juneau	29.74	−.13	30.22	15	28.87	26
Tatoosh Island	29.97	−.04	30.32	16	29.43	31
San Francisco	30.00	−.01	30.19	3	29.82	14
Mazatlan	29.87	+.03	29.98	2	29.76	22
Honolulu	30.01	+.01	30.14	24	29.87	18
Midway Island	30.15	+.12	30.30	24	29.86	31
Guam	29.82	−.02	29.89	25, 26	29.41	11
Manila	29.80	.00	29.92	25	29.62	4, 5
Hong Kong	30.05	+.01	30.22	13	29.84	6, 7
Naha	29.91	+.01	30.09	25	29.71	19
Titijima	29.92	+.01	30.09	1, 28, 29	29.51	16
Petropavlosk	29.76		30.18	28, 30	29.09	15

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observations.

Extratropical cyclones and gales.—While a few cyclones entered middle and northern waters of the North Pacific from Asia during October, the greater number originated and developed over the ocean itself, with centers to the northward of the 40th parallel. Many of these centers were of great depth, with barometer readings below 29 inches on at least 10 days. The deepest developments occurred largely to the eastward of the 180th meridian, and it was in this region that stormy weather was most frequent if not the severest.

The first heavy weather experienced was that of the first few days of October in connection with the deepest storm of the month. This disturbance appeared on the 1st over the central Aleutians. Its center followed an erratic path on the 2d to 4th, then took a decided east to northeast course and entered Alaska north of Kodiak on the 7th. On the 4th to 6th its central pressures were well below 29 inches, and on the 4th and 5th it caused southerly gales of force 11 in the vicinity of 47° to 52° N., 162° W., encountered by the steamships *Michigan* and *Empress of Russia*, as shown in the table of gales.

Another storm at this time lay over the western part of the northern steamer routes and resulted in gales of force 9 to 10 within the approximate area 40° to 50° N., 160° to 175° E., on the 5th and 6th.

From the 7th to 14th scattered gales occurred daily on northern waters, but none was reported that exceeded 8 or 9 in force.

On the 15th and 16th another deep cyclone was central to the southward of the Alaska Peninsula, accompanied by force-10 gales. The lowest barometer, read on the British motorship *Silverguava* in 51° N., 155° W., was 28.21.

On October 17 and 18th an intense cyclone lay over northern waters at and to the immediate westward of the 180th meridian. While only two gale reports of this storm are at hand, yet both show winds of hurricane force, with lowest pressures of about 28.80 inches. The report from the Japanese steamer *San Diego Maru* gives the principal gale encounter near 42° N., 164° E., on the 17th. That from the Japanese motorship *Kunikawa Maru*, Yokohama toward San Francisco, shows that the vessel experienced

gale winds from about 6 p. m. of the 17th until the early morning of the 20th. The ship's lowest pressure, at midnight of the 17th-18th, occurred near 46° N., 171° E. The wind was then southwest, force 11. During the forenoon of the 18th the wind at ship was most of the time of force 11, but for several hours in the afternoon was of hurricane velocity. It very slowly decreased over most of the period thereafter until the 20th, when the ship was near 47° N., 162° W., with the wind still of fresh to strong gale force.

The *Kunikawa Maru* had scarcely escaped this violent storm area than she ran into another of equal wind intensity, but much lower pressure, her minimum barometer being 28.16, in 45° N., 143°34′ W., on the 22d. From early morning until late that night she encountered violent gales, mostly of force 11 to 12 from easterly to westerly directions, thereafter rapidly moderating as the storm moved toward the Gulf of Alaska from the eastern part of the northern steamer routes.

In east longitudes, so far as present reports indicate, stormy weather of extratropical type had ceased by the 20th, but in west longitudes it continued until late in the month. The last severe storm was that of the 26th–27th which overspread northeastern waters and caused scattered gales over a considerable area from the Washington coast southwestward. The strongest gale reported was of force 11 from south-southwest, barometer 29.29, encountered by the Swedish motorship *Dagmar Salen*, in 38°34′ N., 140°38′ W., late on the 26th. Ten degrees to the westward on the following morning the Japanese motorship *Amagisan Maru* had a force-10 gale, barometer 28.94. At the entrance to the Strait of Juan de Fuca on the 26th the Swiftsure Bank Lightship reported a southeaster of force 8. This was one of three strong southeasters reported during the month off the coast of the United States. The first was reported in a special letter to the Weather Bureau by the second officer on the American-Hawaiian steamer *Columbian*. This southbound vessel, after passing St. George's Reef on the 3d, ran into a small depression in which a southeast wind of force 9 was encountered. The third coast gale, of force 8, occurred off the lower coast of Oregon on the 30th.

Tropical cyclones—typhoons.—Elsewhere in this REVIEW appears a report by the Rev. Bernard F. Doucette, S. J., of the Weather Bureau at Manila, P. I., on the Far Eastern typhoons and depressions of October 1938. There remains little to be added except in connection with the typhoon which struck southern Japan on the 21st with considerable loss to life and property. On that day the British steamer *Empress of Canada*, while 50 to 75 miles southeast of Yokohama, ran into the north gales of the typhoon at 4 a. m., then into south winds of hurricane force toward 11 a. m., lowest barometer 28.60. The storm appears to have disintegrated rapidly thereafter, as no trace of it was to be seen on the following day.

Tropical disturbances of the southeastern Pacific.—Two tropical cyclones, of apparently brief existence, occurred in southeastern waters. The earlier was reported only by the American steamer *Ensley City*, Honolulu to Balboa, on the 9th. The ship was under the influence of the disturbance for 11 hours, with changing winds which reached their highest velocity, force 8 from west-northwest, at 4 p. m., lowest barometer 29.43.

The second cyclone was severely encountered by two north-bound Japanese ships, the *Nozima Maru* and the *Asuka Maru*, close off the Mexican coast between Manzanillo and Acapulco, on the 22d. In both instances the advance winds of the storm were experienced from southeasterly directions, quickly changing and rising to highest velocity from the northwest shortly after 8 a. m. On the *Nozima Maru* the heaviest wind was of force 10, lowest barometer 29.64 in and near 17°24′ N., 102°11′ W. On the *Asuka Maru* the wind attained force 11, lowest barometer 29.31, in 17°44′ N., 102°25′ W. Both ships were out of the gale before noon.

Fog.—On the open Pacific remote from land, fog was reported on only 3 days. Along the American coast ships reported fog as follows: Off Washington on 3 days; off Oregon on 2 days; off California on 10 days; off Lower California on 1 day.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST OCTOBER 1938

BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Typhoon, September 28 to October 4, 1938.—A low pressure area formed about 400 miles east-northeast of San Bernardino Strait and intensified into a typhoon after moving along a west-northwesterly course. It inclined to the west-by-north and entered Luzon during the afternoon and evening hours of September 30, passing a short distance south of Tuguegarao, Cagayan Province. It was not very strong at this part of the course, but in the China Sea, it rapidly acquired energy as it continued along a west-by-north course. On October 2 and 3, it was almost stationary about 90 miles east of Hainan Island, until the afternoon hours (October 3) when it proceeded a short distance to the northeast. A change to the west-northwest carried the storm into the continent where it disappeared over the regions north of Hainan Island. After the storm center passed the Philippines, no reports of serious damage were received.

On September 30, when the center crossed northern Luzon, surface winds from stations affected by the storm were not stronger than force 3, and the pressure values varied between 748 mm and 750 mm (29.449 and 29.528 inches). This was due to the mountainous nature of the region, which also caused the winds to be very irregular, so that hardly any indication of circulation was apparent.

When this typhoon formed, the typhoon of September 16–29, 1938, was disappearing over the Formosa Channel and consequently a southwesterly current had been flowing over the Archipelago. A front appeared, extending east to west across the China Sea and northern Luzon, Aparri reporting northeast and east quadrant winds, while Manila and southern stations remained in the southwesterly current. Velocities at Aparri were between 30 and 45 k. p. h. as the typhoon passed about 60 miles south of the station, altitudes of 2,100 and 3,500 m being attained. The strength of the southwest winds increased from values between 20 and 40 k. p. h. to about 60 k. p. h. (at Cebu, September 30) as the storm crossed Luzon, afterwards decreasing. On October 1 and the following days, when the typhoon was moving across the China Sea, the upper winds over northern Indo China were from the northwest, north, and northeast with velocities as high as 60 k. p. h. Over southern Indo China was the extension of the front over Luzon, which separated these northerly winds from the southwesterly current flowing over Saigon and the stations of Siam, where velocities as high as 90 k. p. h. were reported before October 5, afterwards decreasing.

Typhoon, September 30 to October 9, 1938.—This typhoon appeared about 200 miles south-southwest of Guam, apparently well developed, moving along a west-northwesterly course, and gradually inclining to the west-by-north as it moved. In 3 days it was about 600 miles east

of San Bernardino Strait, from which position it moved toward the southwest, thus threatening Samar Island and the regions around Surigao Strait. It seemed to be moving west for a short time as it approached Surigao Strait, but actually, it had changed to a course almost parallel to the eastern coast line of Samar, that is, approximately north-northwest or northwest. An inclination to the west-northwest occurred after the center had passed the eastern part of San Bernardino Strait, which carried it between Catanduanes Island and southern Luzon. Its further movement was practically northwest, bringing the center to the Luzon coastline a short distance south of Baler, Tayabas Province. It changed to the west, thus crossing Luzon south of the mountainous regions, and changed again to the north-northwest as it entered Lingayen Gulf. Another shift occurred very soon to the west, when the center was about 90 miles northwest of Baguio, Mountain Province. A rapid movement took the storm to the region of the Paracels, where it inclined to the northwest and entered the Continent a short distance north of Phulien, moving west-by-north, after which no trace of it could be found.

Baler, Tayabas Province, reported a barometric minimum of 726.01 mm (28.583 inches) with south-southeast winds force 12 (October 6, 12:13 a. m.). After the winds had shifted from the northwest quadrant to north and then were changing to the southeast quadrant, a lull of about 15 seconds was observed, just before the fury of the south-southeast winds arrived. Cabanatuan, North Ecija Province, reported 746.46 mm (29.388 inches) as the minimum, with west winds, force 4, at midnight. Dagupan, Pangasinan Province, had 742.29 mm (29.224 inches) with southwest winds, force 5, as its lowest value, occurring at 3:15 a. m. October 6. San Fernando, La Union Province, at 4 a. m., had a value of 741.59 mm (29.197 inches) as the minimum.

The total number of deaths due to this storm was about 33, the greatest loss being due to the foundering of the motorboat *Dumaguete* near Oslob, Cebu Province. The passengers and crew left the motorboat in three lifeboats, two of which reached shore, the third, however, being lost, with 12 people aboard.

Over Guam, September 30 and October 1, the upper winds were from the east and southeast quadrants, velocities increasing from values close to 25 k. p. h. to 60 k. p. h. and then decreasing after October 2. Over the Philippines an easterly current, in advance of the typhoon, replaced the southwest winds which had prevailed since the preceding typhoon. Aparri, north of the typhoon track, had east-southeast and southeast winds, increasing in velocity to 70 k. p. h. as the typhoon entered the China Sea, October 6. At Manila the upper winds changed from the southwest quadrant to the east quadrant, October 4, velocities ranging from 15 to 50 k. p. h. When the typhoon center was 200 miles east-by-south of Manila, a balloon was followed to the altitude of about 2,000 m, indicating winds from the north-northwest veering to north-northeast, with velocities varying from 25 to 50 k. p. h. Cebu and Zamboanga had southwest quadrant winds during the whole period, Cebu reporting velocities higher than Zamboanga, the former station having values as high as 65 k. p. h. on October 6, decreasing afterwards. This current from the southwest remained over the Philippines until the typhoon disappeared into the continent.

Typhoon, October 7 to 16, 1938.—A low-pressure area moved in a generally west-southwesterly direction from a location about 250 miles west-northwest of Guam. It changed to the west October 9, and then to the north-northwest the next day, when it reached the latitude of San Bernardino Strait. October 11 found it about 350 miles east of northern Luzon, definitely a typhoon, and moving rapidly north-northwest, passing about 60 miles east-northeast of Ishigakijima, Nansei (Loochoo) Islands during the early hours of October 12. An inclination to the northeast and east-northeast, a sudden shift to the east, and the storm was north of Naha, Nansei Islands. Here, it began its course over the Pacific, moving east-northeast at first, and then inclining to the east after it passed southern Japan.

During the formation of this storm, when it was a low-pressure area, Guam had southwest quadrant winds, changing to the southeast as the disturbance moved toward the Philippines. Velocities reported were not over 35 k. p. h. The Philippine stations showed the presence of two currents, Aparri in the northeast quadrant current, Manila, Cebu, and Zamboanga in the southwest quadrant winds. Aparri had velocities between 10 and 35 k. p. h. increasing to 50 k. p. h. on October 14, then weakening. The southwest quadrant current over the southern part of the archipelago had velocities often as high as 50 k. p. h. during these days, the highest values reported being 85 k. p. h. from Cebu on October 12. The few observations received from Tarakan, Borneo, confirmed the supposition that velocities decreased over stations southwest of Cebu, for almost all the time Zamboanga had weaker winds aloft than Cebu. Manila, likewise, did not have the velocities reported by Cebu. A study of the situation indicates that the southwest winds were flowing along the easiest path, that is, over the locality of San Bernardino Strait, to the typhoon center. When the typhoon reached the eastern sea, October 12 to 14, it caused a powerful northeast quadrant current to flow southward. This affected the upper winds over Hong Kong and northern Indochina, and on October 15, it changed the directions at Siam stations and Saigon, Indochina, to the east quadrant, which until that time had southwest quadrant directions. Velocities at Shanghai, reported from U. S. S. *Augusta*, reached values as high as 79 k. p. h. on October 16.

Typhoon, October 12 to 20, 1938.—A depression appeared east-northeast of Guam, and moved in a westerly direction for three days. It recurved to the north-northeast and northeast when about 500 miles east of northern Luzon, at the same time intensifying into a typhoon. When the center reached the locality north of the Bonin Islands, it probably filled up, but observations are not available for confirmation.

At Guam, there were west and southwest winds, velocities increasing to approximately 50 k. p. h. on October 12 and then decreasing.

Depression, October 15 to 17, 1938.—Appearing south of the Bonins, this depression moved in an irregular course toward the north-northeast to the regions about 600 miles northeast of these islands where it disappeared. According to observations available, it was not intense.

Typhoon October 19 to 21, 1938.—This storm appeared rather suddenly, undoubtedly of typhoon strength, about 300 miles east-southeast of Naha, Nansei Islands. It apparently formed as a secondary to the typhoon of October 12 to 20 and may have been developing for some time before the stations of the Nansei Islands were affected. It moved north, then north-northeast, thus approaching the locality of Tokyo (afternoon of October 21), then changed to the east, after which observations were lacking and its further movement and history undetermined.

Newspaper dispatches from Japan reported that nearly 250 lives were lost, and about 35,000 people rendered homeless as a result of this typhoon.

LATE REPORT: TYPHOONS AND DEPRESSIONS OVER THE FAR EAST, SEPTEMBER 1938

Bernard F. Doucette, S. J.

[Weather Bureau, Manila, P. I.]

Depression, August 23 to September 2, 1938.—This depression appeared over the distant ocean regions near latitude 32° N., longitude 162° E., and moved in a generally westerly direction for 7 days. On August 30, when about 250 miles north-northeast of the Bonins, it changed its direction to the northwest, crossed Japan and inclined to the north when over the Sea of Japan. On September 2, it shifted to the east-northeast and apparently weakened as it passed beyond the region of observation.

The observatory staff is indebted to the officers of the S. S. *Gertrude Kellogg* and the S. S. *Silverwalnut* for detailed observations made during the progress of this storm, which were made available when the ships arrived in Manila. Both ships were following the storm center, the S. S. *Silverwalnut* moving along a southwesterly course and crossing the depression track to the east of the center, the S. S. *Gertrude Kellogg*, however, traveling along a course parallel to and south of the depression center. Both ships had winds of force 7 and 8 with rough seas, rainy and squally weather. The minimum pressure reported by the S. S. *Silverwalnut* was 29.67 inches, in latitude 28°40′ N., longitude 151°50′ E., on August 26 at 0600 Greenwich civil time. The S. S. *Gertrude Kellogg* reported 29.76 inches as the lowest pressure, observed in latitude 28°26′ N., longitude 154°36′ E., on August 25 at 0000 Greenwich civil time.

This disturbance appeared to be only a depression as it crossed Japan, but, in news dispatches reaching Manila some days later, it was referred to as a typhoon, which caused the loss of 175 lives on September 1st.

Depression, August 31 to September 5, 1938.—This depression, apparently of minor importance, appeared about 200 miles east-northeast of Guam, moved northwest, then west-northwest and finally west, disappearing about 450 miles east of Basco, Batanes Islands. It is possible that this center recurved and intensified (becoming the typhoon of September 4 to 7), but the available data do not indicate that this happened.

At Guam, the upper winds were from the southwest quadrant until September 5, when they changed to the east and southeast quadrants, the velocities always less than 45 k. p. h. Over the Philippines during the same period there was a rather shallow southwesterly current beneath an easterly air stream. The observations at Aparri, Manila, and Zamboanga showed that the southwest winds extended aloft to approximately the altitude of 4,000 meters, increasing in velocity to about 50 k. p. h. on September 5 and then decreasing. The velocity of the easterly current was always below 40 k. p. h.

Typhoon, September 4 to 7, 1938.—This storm appeared about half way between Naha, Nansei (Loochoo) Islands and the Bonins, the morning of September 4, and seemed to be intense. It moved rapidly northward, crossed Kiu-siu Island and southern Japan, and then inclined to the northeast and east-northeast when it was over the Sea of Japan. It passed over Yezo Island on its course toward the Aleutian Islands.

News dispatches from Japan placed the unofficial total of deaths due to this typhoon at "more than 40", together with great damage due to floods.

Depression, September 7 to 10, 1938.—A weak depression formed about 500 miles east of northern Luzon, moved northwest and then recurved to the northeast and east-northeast, disappearing September 10 near latitude 23° N., longitude 135° E.

The upper air currents over the Philippines were about the same as those described above (depression, August 31 to September 5) except that there was a front extending across northern Luzon. Aparri had north-quadrant winds with velocities never over 40 k. p. h., and changing to the southeast quadrant on September 9. It seems to the writer that intensification was impossible because of the east quadrant airstream above the shallow southwesterly current.

Depression, September 13 to 14, 1938.—A depression formed close to and east of Hainan Island, moved west and then northwest across the Gulf of Tong King into Indochina where it filled up.

Before, during, and after this depression, there was a front over Indochina. Upper winds reported from Phulien, Hanoi, and Vinh were from the northeast and east quadrants, velocities under 45 k. p. h. Southwesterly winds blew over Saigon and Tourane, velocities under 40 k. p. h. Siam stations were similar to Saigon and Tourane. Hong Kong winds showed a persistent easterly air stream.

On September 13 and 14, pressure was lowest and there was definite circulation as shown by the surface winds, but intensification did not take place, very likely because the velocities of the upper winds were not strong enough, as well as for other reasons not known.

Typhoon, September 16 to 29, 1938.—A depression formed over the northern part of the Mariana Islands, moved west by north, was stationary for 2 days near latitude 19° N., longitude 140° E., and then changed its course to the southwest (September 20) thus reaching the ocean regions about 200 miles east of San Bernardino Strait. There it changed its course to the west-northwest, preliminary to recurvature to the northeast, which took place about 250 miles east-northeast of Manila (September 24). On September 26, it intensified to typhoon strength, and then inclined to the north for a short time. During the forenoon hours of September 27, it was moving west-northwest, a course which took it across southern Formosa and the Formosa Channel. It entered China about 60 miles northeast of Swatow and quickly filled up.

The upper winds over Guam on September 15 and the following days were from the southwest quadrant, changing to the west on September 17. The velocities were under 40 k. p. h. before September 17 but increased to values as high as 70 k. p. h. on the 18th (the period when the storm center was stationary). On September 20, the velocities were decreasing. Over the Philippines there was a front extending northeast to southwest and passing over the locality of San Bernardino Strait. On September 25 this front moved northward and was located over the Balintang Channel on September 27. Southwest quadrant winds were reported from Cebu and Zamboanga during this whole period, velocities reaching values of 60 and 70 k. p. h. on September 25 and 27. Aparri and Manila had east quadrant winds until September 25 and 26 with velocities as high as 60 k. p. h. (September 23). Then the directions became southwest quadrant, but with an easterly air stream above, shown by the movement of the high clouds almost every day and sometimes by the balloons which indicated that the southwest winds extended to, about 4,000 meters aloft. The U. S. S. *Ramapo* passed about 200 miles north of the storm center, on her course to America, after crossing the Balintang Channel. On September 26 to 28, when she was almost directly north of the center, the upper winds were from the northeast and east directions under 40 k. p. h.

Depression, September 17 to 19, 1938.—Over the ocean regions far to the east-southeast of the Bonins, a depression formed, moved west-northwest for 2 days and weakened, September 19 as it recurved to the northeast after which no trace of it could be found.

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Depression, September 20 to 25, 1938.—A depression appeared about 500 miles northeast of Guam, moved in a northwesterly direction and disappeared about 400 miles east of Naha, Nansei (Loochoo) Islands.

The southwest quadrant current which was flowing over Guam and which had weakened after September 18, now increased in strength, September 20 and following days, reaching velocities as high as 66 k. p. h. (September 21) and then weakening. Observations from the S. S. *Thurland Castle*, traveling along a westerly course and passing some 300 miles north of Guam about this time showed pressure values above 751.0 mm (29.567 inches) and winds from the east or the north quadrants, never over force 3. After September 22, the velocities reported from Guam gradually became weaker, while the directions remained from the southwest quadrant.

Typhoon, September 25 to 28, 1938.—Forming quickly about 300 miles east of southern Indochina, near latitude 12°30′ N., longitude 114° E., a depression moved along a west-northwesterly direction, intensified September 26, and passed close to and south of Tourane as it entered Indochina. It filled up during the afternoon hours of September 28 over the regions southwest of the Gulf of Tong King.

The lowest pressure reported from Indochina stations as this disturbance formed and moved into the continent, was 747.0 mm (29.410 inches) from Hue, and 747.1 mm (29.414 inches) from Quangngai, September 27, 2 p. m. (Manila time). Winds were of force 3 and 7, respectively, from the northeast quadrant, but other stations reported force 9 at various times during the course of the typhoon.

There was a front extending across the southern part of Indochina during this period. A northeasterly air stream flowed over Phulien, Hanoi, at times tending to back to the northwest quadrant. Saigon consistently reported southwest-quadrant winds, but did not report every day. Velocities on both sides of the front were not strong, scarcely ever exceeding 45 k. p. h. Siam stations during these days had southwest and west quadrant winds, which were not very strong, but an unbroken series of ascents is not available. Likewise, insufficient reports from Malaya stations prevent any discussion of the air streams over that locality during this storm's existence.

SEA-SURFACE TEMPERATURE SUMMARY FOR AN AREA NORTHEAST OF THE BAHAMA ISLANDS, 1912-31

By GILES SLOCUM

The area embraced in this summary comprises five 1° squares, namely; from 25° N. to 30° N., and 74° W. to 75°W. This area is in the latitude of the Florida Peninsula, and its southern part is directly east of the northernmost Bahama Islands. It is just north of the northern margin of the Bahama, or Antillean Current as it approaches the Gulf Stream. This trans-Bahama strip is therefore one nearly isolated from continental weather influences and is, in addition, outside the main sea currents supplying warm water to the North Atlantic Drift.

There are several points of difference and several of similarity between surface water temperature conditions in this eastward area and those in the parallel [3] 5° by 1° strip, traversed by the Gulf Stream, within the same latitude range, immediately east of the Florida Peninsula. Some of these similarities and differences are as follows:

In the Florida Strait-Gulf Stream waters, the surface temperature shows no significant gradient with latitude. In the trans-Bahama strip, the water is about a degree cooler in summer at latitude 30° than at 25°. In winter, this temperature difference becomes several degrees. As a consequence, while in winter [4] the surface water in the latter area is as warm in its southern part as that in the strait, it is at least 3° cooler at the 30th parallel during this season. In summer, the trans-Bahama water surface is cooler throughout its latitudinal extent than is the Florida Strait water. The Gulf Stream water surface fluctuates in temperature about its seasonal normal more than does the surface water in the trans-Bahama area, and departures from normal are more persistently of the same sign in the latter, showing much less tendency to change with fluctuations of air temperature over the Southeastern States.

Temperatures are given to tenths of a Fahrenheit degree in the table, except for 1918. For this year only 41 observations are available, so the temperatures are given to whole degrees. No data could be found for September and October, 1918. In computing means, the interpolated temperatures, 82.0° for September 1918, and 80.1° for October 1918, were used.

This is the twelfth of a series of temperature-history tabulations of this character, showing sea-surface temperatures for small areas in American and western North Atlantic waters. The first of the series appeared in the November 1934 MONTHLY WEATHER REVIEW, and the last previous tabulation appeared in the June 1938 issue.

[3] Slocum, Giles: Sea-Surface Temperature Summary for the Outer Florida Strait, 1912-33; MONTHLY WEATHER REVIEW, vol. 64, Aug. 1936, p. 279.
[4] Ibid: The Normal Temperature Distribution of the Surface Water of the Western North Atlantic Ocean; MONTHLY WEATHER REVIEW, Vol. 66, Feb. 1938, pp. 39-43.

Monthly and annual mean sea-surface temperatures northeast of the Bahama Islands, 1912-31

Year	Total number of observations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1912	251	74.3	72.1	74.0	75.0	77.3	80.6	80.7	81.9	82.2	81.4	76.8	76.5	77.7
1913	234	74.7	74.3	74.6	73.1	75.1	77.3	80.7	80.9	80.2	78.4	76.6	72.8	76.6
1914	199	71.4	72.1	71.6	73.4	74.1	80.2	82.1	83.1	81.5	79.5	77.1	75.9	76.8
1915	266	73.7	72.6	68.9	70.7	76.0	79.3	81.8	83.0	83.0	81.0	77.3	73.2	76.7
1916	192	72.1	72.6	71.5	71.6	75.3	78.4	80.9	82.3	81.6	78.8	75.8	72.1	76.0
1917	154	72.5	71.6	72.2	72.1	74.6	78.0	80.6	81.8	81.5	80.5	74.9	71.7	76.0
1918	41	70	72	72	73	75	74	87	82	(2)	(2)	77.0	76.5	[1] 76.8
1919	124	72.5	72.3	72.3	71.4	75.4	79.2	81.9	82.2	82.2	81.7	77.3	75.0	77.0
1920	227	72.5	71.5	70.9	73.7	75.1	78.2	80.9	82.1	81.7	79.5	76.5	75.4	76.5
1921	255	74.1	72.5	74.2	74.2	74.8	78.2	81.2	81.9	81.9	80.8	77.5	74.9	77.2
1922	371	72.7	71.9	72.2	73.8	75.6	79.6	80.8	81.6	81.8	80.4	78.0	75.5	77.0
1923	585	72.8	71.9	72.3	73.8	75.6	78.7	80.7	82.0	82.5	79.3	75.2	73.7	76.5
1924	653	73.3	70.5	70.8	72.1	77.9	80.2	81.6	82.5	81.1	79.2	76.4	74.0	76.6
1925	709	73.2	72.5	72.8	73.7	75.9	79.3	81.0	82.5	82.6	80.6	77.4	74.9	77.2
1926	825	73.6	72.5	72.2	74.2	76.2	79.7	82.2	83.3	83.1	80.8	78.1	75.8	77.6
1927	908	72.0	74.6	72.2	72.9	76.5	80.4	81.7	82.3	82.0	79.7	76.8	73.7	77.1
1928	1,011	72.4	72.7	72.8	73.0	74.3	78.9	81.4	82.7	82.4	80.5	77.4	74.6	76.9
1929	912	73.1	73.1	73.4	74.8	77.0	78.5	80.7	81.8	81.8	79.5	77.4	75.3	77.2
1930	838	74.6	72.2	72.3	73.3	76.0	77.9	81.1	82.2	82.3	79.7	76.8	74.2	76.9
1931	824	71.6	70.8	69.8	72.9	74.9	78.5	82.0	83.4	83.0	79.9	75.7	75.3	76.5
Number of years of record	----------	20	20	20	20	20	20	20	20	19	19	20	20	20
Mean, 1912-31	----------	72.8	72.3	72.1	73.1	75.7	78.8	81.5	82.3	82.0	80.1	76.8	74.5	76.8

[1] Means were computed, using interpolated values for missing months. All monthly means were carried to one decimal place when computing annual and period means, which latter are, therefore, not exact means of figures given in the body of the table.
[2] No data.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Table 1.—*Condensed climatological summary of temperature and precipitation by sections, October 1938*

[For description of tables and charts, see Review, January, p. 29]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	66.7	+2.0	3 stations	97	6	St. Bernard	26	25	0.33	−2.69	Marion	1.62	15 stations	0.00
Arizona	61.4	−.2	6 stations	103	[1] 1	Alpine	13	19	.11	−.75	Mount Trumbull	1.04	38 stations	.00
Arkansas	66.8	+4.2	2 stations	105	1	Mount Ida	20	24	.94	−2.22	Higden	4.12	Russellville	.07
California	58.5	−1.9	Cow Creek	103	1	Ellery Lake	8	16	1.61	+.38	Kennett	9.89	13 stations	.00
Colorado	50.1	+3.3	Lamar	95	1	Fraser	0	26	.87	−.20	Hermit	5.22	Sterling	.00
Florida	70.7	−2.3	Ocala	93	[1] 16	Mason	31	25	4.70	+.42	Fernandina	11.97	Mason	.05
Georgia	64.5	−.4	3 stations	95	6	Blairsville	23	26	.70	−2.08	Brunswick	5.61	6 stations	.00
Idaho	48.5	+1.4	4 stations	88	2	Island Park Dam	14	18	2.58	+1.09	Island Park Dam	5.08	Swan Falls	.60
Illinois	60.3	+4.7	3 stations	96	5	Jacksonville	24	24	1.36	−1.23	Carlinville	4.31	Olney	.22
Indiana	58.3	+3.5	Sholas	96	[1] 11	Marengo	22	25	.83	−1.94	Farmersburg	2.04	2 stations	.30
Iowa	59.4	+7.8	2 stations	97	[1] 3	Red Oak	20	24	.88	−1.47	Bloomfield	3.27	Shenandoah	.03
Kansas	64.8	+7.7	3 stations	100	4	Oberlin	11	23	.33	−1.58	Iola No. 2	2.05	4 stations	.00
Kentucky	59.9	+1.7	Paducah	95	5	Greensburg	24	25	.45	−2.27	Owensboro Dam 46	1.31	2 stations	.00
Louisiana	69.8	+1.4	Plain Dealing	103	1	Robeline	26	24	1.32	−2.01	Port Eads	4.36	Colfax	.21
Maryland-Delaware	56.6	+.6	Western Port, Md.	92	17	Oakland, Md.	19	8	1.97	−1.05	Snow Hill, Md.	3.90	Mount Savage Summit, Md.	.74
Michigan	52.7	+3.6	Monroe	89	17	Roscommon	14	7	1.17	−1.70	Marquette	3.43	Eau Claire	T
Minnesota	52.9	+6.5	Milan	95	3	Angus	10	23	.51	−1.33	Taylor Falls (near)	1.83	2 stations	T
Mississippi	67.2	+1.8	Mason	98	6	Duck Hill	27	25	.82	−1.81	Port Gibson	2.81	Walnut Grove	.00
Missouri	63.9	+6.4	Sikeston	99	5	Goodland	19	24	1.23	−1.65	Mountain Grove	4.16	Conception	T
Montana	47.5	+2.8	2 stations	88	[1] 2	Butte	5	18	1.75	+.72	Hebgen Dam	6.22	Broadus	.15
Nebraska	59.3	+7.7	3 stations	98	[1] 1	Gordon	5	23	.18	−1.30	Ashland	1.84	17 stations	.00
Nevada	51.4	+.9	Las Vegas	94	1	Sheldon	17	17	1.32	+.75	Lamoille	4.21	3 stations	T
New England	52.5	+3.0	Fitchburg, Mass.	91	12	3 stations	10	[1] 8	2.40	−1.13	East Wareham, Mass.	4.39	Northfield, Vt.	.91
New Jersey	56.2	+1.5	Flemington	93	17	do	24	[1] 2	2.47	−.94	Indian Mills	3.52	New Milford	1.72
New Mexico	54.7	+.9	2 stations	95	[1] 1	Elizabethtown	5	27	1.10	−.03	Clovis	5.00	11 stations	.00
New York	52.4	+2.4	do	89	17	Indian Lake	13	7	1.30	−2.00	Port Jervis	3.05	Rochester	.14
North Carolina	59.5	−.4	do	92	18	Mount Mitchell	22	21	1.33	−2.04	Swansboro	4.68	Nantakala	.02
North Dakota	50.9	+7.1	Napoleon	95	3	Linton	4	23	.55	−.46	Crosby	2.07	Oakes	.03
Ohio	55.8	+2.4	2 stations	90	[1] 16	Canfield	22	31	.68	−1.86	Willoughby	2.01	Batavia	.09
Oklahoma	67.9	+5.5	3 stations	103	[1] 1	Smithville	16	24	.52	−2.41	Boise City	2.42	3 stations	.00
Oregon	50.0	+.3	2 stations	87	[1] 1	Chemult	10	16	2.06	+.16	Seaside	9.30	Canyon City	.11
Pennsylvania	54.5	+2.0	Bethlehem	91	17	Somerset	16	31	1.81	−1.42	Orwigsburg	3.67	Center Hall	.60
South Carolina	63.1	−.7	Laurens	92	9	Longcreek (near)	29	25	1.09	−1.95	Georgetown	2.75	2 stations	T
South Dakota	55.9	+7.4	Pukwana	99	3	Cottonwood	8	22	.16	−1.00	Custer	.58	do	.00
Tennessee	61.7	+2.1	Moscow	95	6	Rugby	23	25	.57	−2.30	Halls	1.75	Fayetteville	T
Texas	70.6	+2.9	Cameron	106	2	Mount Pleasant	27	24	.87	−1.89	Hereford	5.62	4 stations	.00
Utah	50.2	+1.2	Springdale (Zion Park).	91	15	Silver Lake	9	19	1.70	+.60	Silver Lake	4.80	Hanksville	.00
Virginia	57.1	−.2	3 stations	92	[1] 17	Burkes Garden	22	[1] 8	1.23	−1.77	Wallaceton	3.07	Wytheville	.31
Washington	50.9	+1.4	Benton City	92	3	Stockdill Ranch	19	16	3.55	+.36	Wynoochee Oxbow	17.87	Rock Island	.26
West Virginia	55.0	+.4	Grafton	92	18	Bayard	15	[1] 8	.89	−1.96	McNeill	1.92	Lewisburg	.12
Wisconsin	53.0	+4.8	2 stations	89	[1] 9	River Falls	15	24	1.32	−1.14	Rest Lake	4.90	Wauston	.23
Wyoming	47.6	+4.0	Metz Ranch	93	2	2 stations	1	[1] 18	1.17	+.08	Tower Falls	6.57	2 stations	.00
Alaska [September]	47.6	+3.9	Richardson	84	15	Rapids	19	30	4.94	+1.47	Cordova	41.86	Richardson	.26
Hawaii	74.8	+1.0	Hakalau	92	16	Kanalohuluhulu	48	[1] 2	5.81	+.47	Eke	26.00	3 stations	.00
Puerto Rico	78.2	−.2	Ponce	97	23	2 stations	58	[1] 10	7.81	−.27	Toro Negro	21.43	Mona Island	2.10

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, October 1938*

[Compiled by Annie E. Small, by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							53.9	+2.9										80	2.32	−1.0										5.0		
Eastport	75	67	85	29.99	30.07	+0.07	50.0	+2.5	75	12	56	36	23	44	26	47	44	86	2.08	−1.5	7	9.9	sw.	40	s.	24	8	8	15	6.3	0.0	0.0
Greenville, Maine	1,069	4	41	29.01	30.10		47.0		84	12	58	20	31	36	44	42	39		2.73	−.9			nw.									
Portland, Maine	103	82	117	29.97	30.09	+.05	53.2	+3.3	83	17	60	36	31	46	31	46	42	71	2.74	−.4	5	8.0	n.	29	s.	24	16	9	6	4.1	.0	.0
Concord	289	54	72	29.78	30.10	+.05	53.9	+4.2	86	12	66	28	8	42	40				2.07	−.8	4	5.1	ne.	21	w.	25	13	11	7	4.6	.0	.0
Burlington	403	11	48	29.66	30.10	+.06	49.6	+.4	77	13	59	28	31	40	30	46	43	82	1.37	−1.6	7	8.4	s.	29	s.	23	7	12	12	6.1	.0	.0
Northfield	876	12	60	29.15	30.12	+.08	47.8	+2.3	82	12	62	20	31	34	43	42	40	85	.91	−2.0	6	6.3	sw.	21	s.	24	6	16	9	5.9	.0	.0
Boston [1]	29	33	62	30.04	30.07	+.02	56.0	+2.4	87	17	63	38	7	49	30	50	46	77	2.43	−.7	10	11.1	ne.	33	ne.	30	10	10	11	5.6	.0	.0
Nantucket	12	14	90	30.04	30.05	.00	56.0	+1.8	77	12	61	45	26	51	22	53	51	89	3.79	+.4	10	17.2	n.	46	n.	31	12	5	14	5.7	.0	.0
Block Island	26	11	46	30.04	30.07	+.02	56.4	+1.5	73	12	62	43	31	51	20	52	49	80	2.94	−.6	9	16.8	ne.	44	ne.	30	17	4	10	4.1	.0	.0
Providence	159	215	251	29.90	30.08	+.03	56.6	+4.4	86	17	64	38	8	49	30	50	46	76	3.01	−.1	7	10.9	nw.	31	nw.	21	14	9	8	4.5	.0	.0
Hartford	159	66	100	29.92	30.09	+.03	56.6	+5.4	87	17	66	34	8	47	36				1.56	−2.0	6	7.9	n.	23	ne.	28	18	5	8	4.1	.0	.0
New Haven	106	74	153	29.98	30.09	+.03	57.2	+3.4	86	17	66	35	8	48	31	51	47	77	2.16	−1.5	7	7.4	n.	21	ne.	30	14	10	7	4.3	.0	.0
Middle Atlantic States							57.5	+1.2										74	1.81	−1.2										4.1		
Albany [1]	292	26	37	29.78	30.09	+.03	52.6	+.5	82	17	64	27	8	42	37	46	43	78	1.18	−1.6	5	8.4	n.	26	nw.	25	12	8	11	5.2	.0	.0
Binghamton	871	57	79	29.19	30.13	+.07	53.2	+3.2	82	17	65	27	8	41	40	46	43	80	.96	−2.0	6	5.3	e.	18	sw.	26	8	11	12	6.2	.0	.0
New York	314	415	454	29.74	30.08	+.02	58.6	+2.3	87	17	67	40	8	50	28	51	45	67	1.63	−1.9	6	12.8	n.	38	nw.	24	16	9	6	3.8	.0	.0
Harrisburg	374	94	104	29.56	30.11	+.03	56.8	+2.0	84	17	67	37	8	47	32	50	45	71	2.42	−.5	6	6.4	n.	21	ne.	28	19	5	7	3.7	.0	.0
Philadelphia	114	174	367	29.98	30.10	+.03	59.3	+1.5	89	17	68	42	8	50	30	51	46	71	2.09	−.7	5	12.5	n.	37	n.	28	16	8	7	3.9	.0	.0
Reading	323	283	306	29.76	30.12		57.8	+3.1	86	17	68	35	8	48	31	50	45	69	2.49	−.6	6	9.7	n.	34	ne.	28	17	6	8	3.8	.0	.0
Scranton	805	72	104	29.24	30.11	+.04	54.3	+2.4	83	17	65	30	8	43	37	47	43	74	1.60	−1.4	6	5.6	n.	21	sw.	26	12	11	8	4.6	.0	.0
Atlantic City	52	37	172	30.02	30.08	+.01	57.8	+.9	78	17	64	40	8	51	27	53	50	80	3.19	.0	7	16.2	ne.	50	ne.	28	13	7	11	4.8	.0	.0
Sandy Hook	22	10	57	30.05	30.07		58.9	+2.0	82	17	65	46	31	52	23	53	49	77	2.09	−1.7	7	13.8	n.	42	ne.	28	16	9	6	3.7	.0	.0
Trenton	190	89	107	29.88	30.09		57.4	+1.8	87	17	67	38	8	48	32	50	46	74	2.27	−.5	6	8.1	n.	23	ne.	28	17	6	8	4.2	.0	.0
Baltimore	123	100	215	29.97	30.10	+.02	59.8	+1.6	90	17	69	42	8	50	34	52	46	68	2.15	−.7	6	9.4	n.	35	ne.	28	18	8	5	3.4	.0	.0
Washington	112	62	85	29.98	30.10	+.02	58.8	+1.4	88	19	69	38	8	48	33	57	46	76	1.15	−1.7	6	5.7	n.	24	nw.	20	18	8	5	3.4	.0	.0
Cape Henry	18	8	54	30.06	30.08		60.0	−2.1	81	20	66	45	22	54	23	56	54	84	2.79	−.2	5	13.4	n.	43	n.	24	15	7	9	4.3	.0	.0
Lynchburg	686	144	184	29.39	30.14	+.05	59.5	+1.0	91	18	73	36	8	46	41	49	45	71	.77	−2.4	5	5.7	nw.	26	nw.	20	20	6	5	2.9	.0	.0
Norfolk	91	170	205	30.00	30.10	+.03	61.2	−1.3	86	19	69	46	22	54	30	54	51	77	2.09	−1.0	8	9.4	n.	26	n.	6	14	6	11	4.7	.0	.0
Richmond	144	11	52	29.96	30.12	+.04	59.2	−.4	87	18	71	37	26	48	35	51	48	80	1.58	−1.3	5	7.2	ne.	24	ne.	28	20	7	4	2.8	.0	.0
Wytheville	2,304	49	55		30.15	+.06	54.4	+.8	84	18	69	31	22	40					.31	−2.5	2	5.5	nw.	21	nw.	27	22	7	2		.0	.0
South Atlantic States							63.8	−0.4										74	2.27	−1.0										2.9		
Asheville	2,253	89	104	27.80	30.16	+.07	57.2	+1.9	85	18	72	32	26	43	42	48	43	72	.22	−2.5	3	6.7	nw.	26	nw.	27	26	2	3	1.8	.0	.0
Charlotte	779	63	86	29.28	30.12	+.04	62.8	+1.1	87	6	74	42	26	51	33	53	47	66	1.60	−1.4	5	6.1	ne.	21	ne.	6	25	1	5	2.3	.0	.0
Greensboro [1]	886	6	56	29.18	30.15		59.0		89	18	74	33	26	45	40	50	46	77	.96		4	6.8	ne.	24	n.	28	21	6	4	2.6	.0	.0
Hatteras	11	5	50	30.05	30.06	.00	63.3	−2.6	80	19	69	52	28	58	20	59	57	84	2.08	−2.9	6	14.2	n.	42	se.	24	15	8	8	4.3	.0	.0
Raleigh	376	103	140	29.69	30.10	+.03	61.3	−.7	86	18	72	42	8	51	31	54	50	75	1.52	−1.3	6	8.4	n.	25	n.	28	19	8	4	2.9	.0	.0
Wilmington	72	73	107	30.01	30.08	+.02	63.4	−1.9	86	18	73	43	8	54	30	56	53	79	1.48	−1.8	6	7.7	n.	25	nw.	24	19	6	6	3.3	.0	.0
Charleston	48	11	92	30.03	30.08	+.02	65.8	−2.0	82	18	73	48	28	58	28	59	56	77	2.63	−.6	3	10.1	n.	27	ne.	15	17	9	5	3.5	.0	.0
Columbia, S. C.	347	70	91	29.73	30.11	+.04	64.3	.0	87	6	76	42	22	53	32	55	49	66	1.30	−1.3	3	7.4	ne.	23	ne.	7	23	5	3	2.1	.0	.0
Greenville, S. C.	1,040	70	78	29.01	30.11		63.0	+2.8	88	6	75	41	26	51	34	52	46	62	.41	−2.7	3	5.7	ne.	17	n.	27	24	2	5	2.1	.0	.0
Augusta	182	62	77	29.89	30.08	+.01	65.2	−.1	89	9	78	40	26	52	42	55	50	70	.86	−1.6	2	4.9	ne.	18	ne.	7	21	7	3	2.5	.0	.0
Savannah	65	73	152	30.00	30.07	+.02	67.4	−.5	87	20	77	47	29	58	34	59	56	79	1.67	−1.3	3	9.2	ne.	27	e.	15	20	4	7	3.1	.0	.0
Jacksonville	43	86	110	30.00	30.05	+.03	68.2	−2.9	84	20	76	48	28	60	27	61	59	81	11.21	+6.8	8	8.1	ne.	23	nw.	24	13	10	8	4.8	.0	.0
Florida Peninsula							74.6	−1.6										77	4.57	−1.2										4.5		
Key West	21	10	64	29.92	29.94	.00	79.0	−.1	89	24	84	64	30	74	15	71	69	76	2.63	−3.4	9	11.0	ne.	24	e.	11	15	9	7	4.0	.0	.0
Miami	25	124	168	29.93	29.96	−.01	75.8	−1.2	86	21	82	53	29	70	27	69	66	76	5.28	−3.2	13	11.1	ne.	25	e.	10	12	10	9	5.1	.0	.0
Tampa	35	88	197	29.96	30.00	+.02	72.0	−2.3	89	16	80	54	26	64	23	65	62	79	6.94	+3.8	6	12.4	ne.	40	sw.	24	13	9	9	4.5	.0	.0
Titusville	43	5	36				71.6	−2.6	88	16	81	48	29	62	30	65	63		3.43	−2.2	12		ne.				10	12	9		.0	.0
East Gulf States							67.8	+1.0										67	0.77	−2.1										3.0		
Atlanta [1]	976	5	53	29.07	30.09	+.02	64.2	+1.2	91	6	77	41	22	51	36	53	48	69	.20	−2.4	1	7.5	nw.	27	n.	27	23	5	3	1.9	.0	.0
Macon	370	79	87	29.70	30.09	+.03	65.3	+.8	91	6	79	38	26	52	43	54	48	65	.47	−1.9	2	6.0	nw.	21	e.	15	24	5	2	2.0	.0	.0
Thomasville	273	49	58	29.77	30.07	+.03	66.6	−1.6	87	20	78	44	29	56	32	59	55		1.61	−1.4			ne.				21	3	7	3.2	.0	.0
Apalachicola	35	11		30.00	30.05		68.5	−2.1	87	1	76	49	25	61	24	62	59	79	2.29	−.9	4	9.3	ne.	26	ne.	15	17	6	8	3.8	.0	.0
Pensacola	56	149	185	30.00	30.06	+.03	69.6	−.3	89	7	77	47	25	62	24	60	55	66	.48	−3.7	2	11.6	ne.	26	ne.	15	17	7	7	3.4	.0	.0
Anniston	741	9					64.6	+2.2	91	6	78	34	25	51	41				.53	−2.1	2		nw.				26	3	2		.0	.0
Birmingham	700	11	48	29.35	30.09	+.02	68.0	+3.2	93	6	81	39	25	55	34	55	47	57	.05	−2.4	1	5.6	e.	15	s.	22	25	3	3	1.9	.0	.0
Mobile	57	86	161	30.00	30.07	+.03	69.4	+.1	88	6	80	42	25	59	32	60	55	69	.48	−3.1	3	9.0	n.	22	e.	17	18	4	9	3.8	.0	.0
Montgomery	218	92	105	29.85	30.10	+.04	68.2	+1.6	93	6	80	42	25	56	35	56	49	61	.15	−2.3	1	5.9	e.	18	ne.	15	23	1	7	2.7	.0	.0
Meridian	375	67	92	29.69	30.09	+.03	67.0	+2.7	92	6	80	36	25	54	39	57	52	71	1.42	−1.0	2	4.3	ne.	17	e.	15	19	6	6	2.9	.0	.0
Vicksburg	247	82	102	29.82	30.08	+.02	69.7	+3.0	89	2	80	40	24	59	28	59	52	63	.57	−2.2	4	7.8	e.	17	sw.	22	18	7	6	3.5	.0	.0
New Orleans	53	76	84	30.01	30.06	+.03	72.8	+1.8	91	1	80	55	26	65	24	63	58	66	.96	−2.3	7	6.8	ne.	24	e.	16	18	6	7	3.8	.0	.0
Port Eads, La.	9	4	35																													
West Gulf States							72.2	+4.3										62	0.74	−2.4										2.5		
Shreveport	249	92	227	29.81	30.08	+.03	72.0	+5.4	99	1	84	37	24	60	34	60	53	60	.37	−2.3	5	9.6	e.	25	se.	18	23	5	3	2.5	.0	.0
Bentonville	1,303	12	38	28.72	30.08	+.03	65.6	+7.6	90	6	80	28	24	51	39				.46	−3.2	4	5.5	s.	16	s.	12	25	2	4		.0	.0
Fort Smith	463	57	82	29.62	30.09	+.04	69.0	+6.2	96	1	82	32	24	56	39	55	46	52	1.96	−1.0	4	6.0	e.	17	n.	19	25	3	3	2.4	.0	.0
Little Rock	357	94	102	29.72	30.09	+.03	68.0	+4.4	93	1	80	36	24	56	36	56	47	54	1.37	−1.3	4	6.8	e.	22	sw.	22	23	5	2	4.0	.0	.0
Austin	605	68	90	29.42	30.04		72.7	+4.4	100	2	86	38	24	59	38	61	55	62	.24	−3.0	4	5.5	s.	22	n.	23	22	7	2	2.5	.0	.0
Brownsville	57	88	96	29.95	30.01		76.0	+1.1	94	3	85	51	24	67	25	67	64	75	.81	−2.5	5	8.3	se.	23	n.	23	25	4	2	2.3	.0	.0
Corpus Christi	20	11	78	30.01	30.03	+.03	75.6	+2.4	91	18	84	51	24	68	23	67	64	74	.20	−2.3	3	9.1	e.	27	e.	10	24	4	3	2.1	.0	.0
Dallas	512	220	227	29.50	30.05		72.6		100	1	84	40	23	62	32	58	48	47	.13	−2.6	3	10.0	se.	28	ne.	17	21	9	1	2.4	.0	.0
Fort Worth	679	92	110	29.36	30.06	+.03	73.0	+6.3	101	1	86	37	24	60	39				.11	−2.7	1	7.8	se.	23	n.	19	23	6	2	2.2	.0	.0
Galveston	54	106	114	29.99	30.05	+.02	75.3	+2.6	94	2	81	51	24	70	22	67	64	73	1.26	−3.1	6	9.1	s.	30	ne.	17	21	6	4	2.6	.0	.0
Houston	138	157	190	29.91	30.06		74.0	+3.7	97	2	84	44	24	64	27				1.83	−1.9	4	8.7	se.	27	n.	17	19	8	4	3.2	.0	.0
Palestine	510	64	72	29.54	30.07	+.04	72.0	+4.8	98	1	84	40	24	60	34	59	51	57	.17	−3.2	4	5.7	e.	19	n.	23	21	6	4	2.3	.0	.0
Port Arthur	34	59	134	30.02	30.06		73.6		95	1	82	43	24	65	27	65	62	74	1.37	−2.0	7	10.5	e.	43	e.	17	18	10	3	3.0	.0	.0
San Antonio	693	111	301	29.32	30.04	+.03	73.1	+2.6	96	2	85	41	24	61	33	61	54	59	.13	−2.1	2	10.0	e.	37	se.	5	18	12	1	2.9	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, October 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**59.9**	**+2.2**										**64**	**0.66**	**-2.0**										**2.6**		
Chattanooga	762	71	214	29.30	30.11	+0.02	65.1	+3.2	90	6	79	38	25	51	30	53	45	58	.06	-2.9	2	5.9	ne.	22	n.	27	27	1	3	1.4	0.0	0.0
Knoxville	995	66	84	29.07	30.13	+.04	62.0	+2.1	86	18	76	34	25	48	30	52	46	68	.50	-2.1	2	4.3	ne.	15	ne.	6	27	2	2	1.2	.0	.0
Memphis	399	78	86	29.67	30.09	+.02	68.0	+4.7	90	5	79	37	24	57	30	56	48	55	.38	-2.3	3	6.2	e.	21	sw.	22	22	6	3	2.3	.0	.0
Nashville	546	168	188	29.55	30.14	+.06	63.3	+2.3	87	5	76	36	25	50	35	53	46	62	.47	-2.0	3	6.1	ne.	25	sw.	22	24	4	3	1.8	.0	.0
Lexington	989	6					59.4	+2.0	87	18	74	32	25	44	42				.38	-2.2	2		n.				24	3	4		.0	.0
Louisville	525	188	234	29.56	30.14	+.06	60.8	+1.5	84	18	72	38	24	49	31	51	44	61	.49	-2.2	3	8.4	n.	27	e.	22	23	4	4	2.4	.0	.0
Evansville	431	76	116	29.65	30.12	+.04	63.6	+4.2	89	5	76	37	24	51	33	52	44	58	.35	-2.5	3	6.8	e.	28	sw.	22	21	6	4	2.6	.0	.0
Indianapolis	822	194	230	29.24	30.13	+.06	59.4	+3.7	86	15	71	34	24	48	33	48	40	57	1.06	-1.7	3	9.0	s.	30	w.	26	18	9	4	3.1	.0	.0
Terre Haute	575	63	149	29.48	30.10		61.1		88	15	74	34	24	48	34	50	42	61	1.45	-1.3	4	7.7	se.	28	w.	26	23	7	1	1.9	.0	.0
Cincinnati	627	11	51	29.46	30.14	+.06	58.0	+2.3	86	18	71	35	28	45	36	48	43	59	.31	-2.2	5	5.9	ne.	20	w.	26	20	7	4	2.7	.0	.0
Columbus	822	90	210	29.25	30.13	+.05	57.1	+1.9	84	12	70	31	31	45	34	48	42	67	.70	-1.8	5	7.4	s.	31	sw.	26	23	3	5	2.8	.0	.0
Dayton	900	186	213	29.17	30.13		56.8	+1.8	84	17	69	31	31	45	36	48	42	65	.86	-1.7	4	7.7	n.	28	s.	22	22	5	4	2.6	.0	.0
Elkins	1,947	65	83	28.11	30.18	+.08	52.6	+.3	86	18	68	28	26	38	46	44	40	80	1.08	-1.8	7	4.4	n.	21	w.	26	19	5	7	4.3	.0	.0
Parkersburg	637	77	84	29.45	30.14	+.06	56.8	+.7	85	18	70	32	31	44	40	48	44	75	.73	-1.8	5	5.0	nw.	18	se.	26	23	1	7	2.7	.0	.0
Pittsburgh [1]	1,273	39	54	28.77	30.13	+.05	55.1	-.6	83	18	67	30	8	43	38	46	40	67	1.10	-1.4	5	8.8	s.	34	nw.	26	17	6	8	4.2	.0	.0
Lower Lake Region							**54.4**	**+2.3**										**73**	**0.78**	**-2.1**										**4.6**		
Buffalo	768	243	280	29.28	30.12	+.07	53.4	+1.5	76	12	60	36	28	47	23	47	44	75	.37	-2.9	7	12.8	s.	43	w.	26	11	10	10	5.1	.0	.0
Canton	448	10	61	29.62	30.10		49.2	+2.0	78	12	60	23	7	39	30	44	41	80	.87	-2.2	7	7.5	w.	21	sw.	26	10	10	11	5.2	.0	.0
Ithaca	836	77	100	29.21	30.12		53.2	+2.1	83	12	64	28	7	42	37	46	43	77	.59	-2.4	6	7.6	nw.	29	se.	26	8	6	17	6.2	.0	.0
Oswego	335	71	85	29.74	30.11	+.06	52.3	+1.1	82	12	60	30	31	44	28	47	43	76	.80	-2.5	8	8.9	n.	25	n.	30	5	11	15	6.3	T	.0
Rochester	523	86	102	29.55	30.13	+.08	54.4	+2.9	84	12	62	37	31	46	28	47	42	71	.14	-2.5	3	7.4	sw.	24	w.	26	11	7	13	5.6	.0	.0
Syracuse	596	65	79	29.47	30.12	+.06	54.2	+2.6	85	12	64	31	7	45	31				.56	-2.3	6	6.4	s.	18	s.	23	12	8	11	5.1	.0	.0
Erie	714	130	81	29.34	30.12	+.07	56.0	+2.6	82	12	64	35	31	48	22	49	45	75	1.72	-2.0	9	7.7	s.	23	sw.	26	16	7	8	4.3	.0	.0
Cleveland	762	267	318	29.29	30.12	+.06	56.4	+2.8	82	12	64	38	7	49	25	49	43	64	.70	-2.1	7	13.5	s.	41	nw.	26	19	4	8	3.7	.0	.0
Sandusky	629	5	67	29.43	30.12	+.06	55.8	+1.5	85	12	66	33	31	45	31				.75	-1.7	9	7.7	s.	25	sw.	26	19	5	7	3.6	.0	.0
Toledo	628	79	87	29.44	30.13	+.08	56.3	+2.9	84	16	67	34	28	46	31	48	42	67	1.22	-1.2	6	8.0	sw.	27	w.	26	19	9	3	2.7	.0	.0
Fort Wayne	857	69	84	29.20	30.13		56.8	+3.3	84	15	68	33	24	45	32	48	42	66	.66	-1.9	5	7.3	sw.	27	sw.	22	17	9	5	3.5	.0	.0
Detroit [1]	626	5	78	29.43	30.12	+.07	55.0	+2.5	85	16	66	33	28	44	36	48	44	75	.94	-1.4	5	8.2	sw.	29	nw.	26	15	9	7	4.1	.0	.0
Upper Lake Region							**53.2**	**+4.9**										**76**	**1.46**	**-1.2**										**5.1**		
Alpena	609	13	89	29.43	30.10	+.07	50.8	+3.7	83	12	60	30	7	42	32	45	42	80	1.26	-1.4	14	10.3	nw.	38	e.	22	10	11	10	5.3	T	.0
Escanaba	612	41	49	29.40	30.07	+.06	51.2	+5.2	71	14	58	33	22	45	22	47	45	83	2.07	+.3	11	11.7	s.	38	ne.	22	10	5	16	6.1	1.0	.0
Grand Rapids	707	70	244	29.33	30.10	+.06	56.6	+5.4	83	16	67	35	7	46	33	49	44	74	1.49	-1.3	5	10.0	s.	37	sw.	12	13	12	6	4.4	.0	.0
Lansing	878	5	90	29.16	30.11		53.6	+3.3	85	16	65	27	28	42	39	46	42	77	.37	-2.1	4	7.6	s.	25	se.	22	12	14	5	3.9	T	.0
Marquette	734	44	69	29.24	30.05	+.04	51.5	+4.8	85	10	59	32	30	44	30	46	42	77	3.43	+.7	9	8.8	s.	26	s.	7	6	13	12	6.3	6.0	.0
Sault Ste. Marie	614	11	52	29.41	20.11	+.10	49.0	+4.4	81	12	57	31	7	41	31	44	41	81	2.17	-1.6	16	7.6	se.	22	nw.	19	9	6	16	6.0	.3	.0
Chicago	673	7	131	29.37	30.10	+.06	58.8	+4.8	85	10	68	35	24	50	27	50	44	68	.77	-1.8	5	9.5	s.	27	nw.	26	16	10	5	3.4	.0	.0
Green Bay	617	109	141	29.39	30.06	+.04	54.8	+6.3	82	10	63	34	25	46	28	46	43	73	.75	-1.8	6	10.7	s.	30	nw.	26	11	7	13	5.6	.0	.0
Milwaukee	681	97	221	29.34	30.07	+.04	56.6	+5.5	84	16	64	35	24	49	26	50	46	73	.76	-1.6	6	12.5	sw.	32	n.	5	12	12	7	4.8	T	.0
Duluth	1,133	5	47	28.79	30.01	+.01	49.4	+5.3	82	10	57	30	23	42	36	44	40	77	.64	-1.7	4	13.6	ne	43	nw.	26	11	8	12	5.5	.3	.0
North Dakota							**50.9**	**+7.1**										**63**	**0.51**	**-0.7**										**5.9**		
Moorhead, Minn	940	50	58	28.97	30.00	.00	52.1	+7.6	85	9	64	20	23	40	46	44	37	63	.15	-1.5	2	9.5	s.	23	s.	10	13	8	10	4.8	T	.0
Bismarck	1,674	8	57	28.21	30.00	+.01	52.6	+7.7	86	3	65	17	23	40	39	43	34	58	.24	-.7	4	9.2	w.	28	nw.	13	14	9	8	4.3	T	.0
Devils Lake	1,478	11	44	28.42	30.00	+.01	49.4	+7.0	84	3	61	20	23	38	43	41	34	64	.38	-.9	6	10.6	nw.	28	nw.	12	14	8	9	4.5	T	.0
Grand Forks	833	12	67				49.0	+5.4	85	9	63	15	23	35	58	42	37		.52	-.9	7	10.0	s.				13	8	10		.0	.0
Williston	1,878	42	50	28.01	30.00	+.02	51.2	+7.8	86	3	62	28	23	41	36	43	37	67	1.26	+.4	6	8.2	w.	27	nw.	13	16	8	7	4.0	9.2	.0
Upper Mississippi Valley							**59.9**	**+6.6**										**66**	**1.25**	**-1.2**										**3.3**		
Minneapolis and St. Paul, Minn. [1]	848	32	61	29.10	30.01	.00	55.4	+6.5	86	9	67	26	24	44	38	47	42	72	.84	-1.2	5	11.5	s.	30	n.	22	14	7	10	4.6	1.9	.0
La Crosse	714	11	48	29.27	30.04	+.02	56.3	+6.0	82	4	66	30	24	46	32	49	46	76	1.35	-1.0	6	5.7	s.	16	w.	26	17	6	8	4.0	.1	.0
Madison	974	70	78	29.01	30.06	+.03	55.8	+5.5	84	10	65	33	24	47	27	49	44	73	.76	-1.7	6	8.3	s.	21	ne.	5	13	9	9	4.7	T	.0
Charles City	1,015	10	51	28.96	30.06	+.04	56.2	+7.6	86	4	68	29	24	45	38	48	44	73	.64	-1.7	5	6.5	se.	19	sw.	11	18	8	5	3.4	T	.0
Davenport	606	66	161	29.42	30.08	+.04	60.0	+6.3	87	9	70	34	24	50	31	51	45	66	1.59	-.8	3	9.2	sw.	29	nw.	26	18	8	5	3.4	T	.0
Des Moines	861	5	99	29.14	30.04	+.01	61.6	+8.2	92	4	75	31	24	48	43	51	44	62	1.33	-1.2	6	9.4	se.	29	nw.	26	20	6	5	3.1	.8	.0
Dubuque	699	60	79	29.31	30.06	+.02	57.8	+5.9	85	4	68	32	24	47	34	49	45	72	.95	-1.5	5	5.5	s.	21	nw.	26	18	6	7	3.6	T	.0
Keokuk	614	64	78	29.42	30.08	+.03	62.8	+7.4	90	4	75	33	24	51	34	51	44	59	1.04	-1.2	3	7.0	sw.	22	nw.	22	19	7	5	3.2	.0	.0
Cairo	358	87	93	29.72	30.10	+.03	64.6	+4.2	93	5	77	35	24	52	32	54	47	63	1.16	-1.6	5	6.5	ne.	19	n.	19	24	5	2	2.4	.0	.0
Peoria	609	11	45	29.44	30.11	+.06	60.3	+8.3	88	8	73	31	24	48	35	50	44	68	.84	-1.4	2	5.2	s.	19	w.	26	25	4	2	1.7	.0	.0
Springfield, Ill	636	5	191	29.42	30.10	+.05	62.6	+6.8	88	8	75	34	24	50	33	51	44	60	3.30	+.8	4	10.7	s.	30	nw.	26	20	6	5	3.2	.0	.0
St. Louis	568	179	303	29.49	30.09	+.03	65.5	+6.7	90	15	76	36	24	54	32	52	43	50	1.17	-1.6	4	10.3	sw.	26	sw.	12	25	4	2	1.7	.0	.0
Missouri Valley							**62.7**	**+8.7**										**54**	**0.85**	**-1.4**										**2.9**		
Columbia, Mo	784	6	66	29.26	30.09	+.04	65.1	+8.5	92	4	78	30	24	52	45				.59	-2.0	2	7.1	s.	21	nw.	22	21	8	2	2.9	.0	.0
Kansas City [1]	750	32	45	29.25	30.05	+.01	66.4	+8.7	93	5	80	33	23	53	50	54	45	54	.70	-2.2	2	8.7	sw.	27	nw.	22	19	8	4	3.2	.0	.0
St. Joseph	967	11	49	29.02	30.05		66.1		94	4	80	32	24	52	49	52	43	52	.14	-2.8	2	8.0	s.	24	nw.	22	24	5	2	2.2	.0	.0
Springfield, Mo	1,324	5	78	28.70	30.10	+.05	65.8	+7.6	91	5	78	31	24	54	36	52	43	53	2.86	-.2	3	7.6	se.	19	sw.	12	26	8	2	1.9	.0	.0
Topeka	987	65	87	29.00	30.05		66.2	+9.2	95	4	81	27	24	52	49	52	42	48	.35	-2.1	4	9.0	s.	27	nw.	22	23	8	0	2.2	.0	.0
Lincoln	1,189	11	81	28.76	30.01	-.02	64.4	+10.2	96	3	78	31	23	51	47	51	41	49	.40	-1.5	1	9.8	s.	38	nw.	22	20	7	4	3.0	.0	.0
Omaha [1]	982	31	44	28.98	30.03	.00	63.0	+8.7	96	3	77	30	24	49	46	51	43	59	1.52	-.6	3	10.2	s.	36	nw.	22	21	9	1	2.7	.0	.0
Valentine	2,598	47	54	27.31	30.02	+.01	56.0	+6.7	92	2	71	14	23	41	49	45	36	56	.15	-1.0	2	9.6	w.	26	s.	9	14	10	7	4.1	.0	.0
Sioux City	1,138	64	106	28.80	30.01	-.01	60.6	+9.7	96	3	74	26	23	48	47	50	42	56	1.63	-.1	3	9.8	se.	34	s.	11	19	6	6	3.5	T	.0
Huron	1,307	59	74	28.61	30.02	+.01	56.6	+8.9	94	3	70	20	23	44	43	46	38	57	.14	-1.1	4	10.4	s.	27	n.	21	18	8	5	3.8	T	.0
Northern Slope							**49.7**	**+4.7**										**62**	**1.27**	**+0.2**										**5.4**		
Havre	2,507	11	67	27.37	30.01	+.03	50.1	+5.6	82	1	63	26	23	38	42	43	36	66	1.80	+1.1	8	8.7	e.	32	w.	27	9	9	13	5.4	T	.0
Helena	4,124	85	111	25.83	30.07	+.04	45.2	+.3	78	1	54	22	19	37	32	40	35	71	2.27	+1.4	10	6.8	sw.	26	s.	11	1	12	18	7.5	11.7	.0
Missoula	3,263	80	91				48.7	+3.9	79	2	59	29	22	38	34				.91	-.3	14	5.5	s.	27	w.	13	6	7	18	6.8	T	.0
Kalispell	2,973	48	56	26.99	30.06	+.05	46.0	+2.5	71	1	56	27	23	36	33	42	38	74	.80	-.3	10	5.6	nw.	23	sw.	11	9	8	14	6.2	.0	.0
Miles City	2,371	48	55	27.51	30.00	.00	53.4	+6.9	84	2	65	26	23	42	40	44	36	60	.76	-.1	6	6.3	s.	28	nw.	25	11	8	12	5.2	1.1	.0
Rapid City	3,259	50	58	26.65	30.00	-.01	55.4	+6.9	86	3	67	23	23	44	42	45	34	48	.24	-.7	3	7.7	w.	26	s.	20	16	9	6	4.0	.0	.0
Cheyenne [1]	6,144	5	39	24.02	30.03	+.02	49.7	+4.9	78	1	64	18	23	36	41	40	32	57	.54	-.4	6	11.0	w.	34	w.	12	13	9	9	4.6	2.2	.0
Lander	5,352	60	68	24.70	30.03	-.01	48.8	+5.3	77	1	62	25	19	36	41	39	31	58	1.23	-.1	6	4.5	sw.	24	sw.	11	10	9	12	5.0	5.9	.0
Sheridan	3,790	10	47	26.13	30.04		50.1		84	3	66	20	23	35	50	41	33	61	.41	-.7	7	4.9	s.	24	nw.	11	11	13	7	5.0	.2	.0
Yellowstone Park	6,241	12	46	23.96	30.17	+.15	41.0	+1.3	67	1	51	11	19	31	33	35	31	74	4.98	+3.8	15	6.7	sw.	34	sw.	5	10	5	16	6.0	11.5	.0
North Platte	2,821	11	51	27.11	30.02	.00	58.7	+9.0	92	2	75	16	23	43	48	46	37	54	.03	-1.0	2	7.4	s.	26	ne.	28	18	6	7	3.7	T	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, October 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Middle Slope							**63.2**	**+7.2**										**46**	**0.16**	**−1.6**										**3.0**		
Denver	5,292	106	113	24.79	30.03	+0.02	56.0	+4.8	82	15	68	27	23	43	39	43	31	44	.12	−.9	5	7.6	s.	23	s.	7	10	12	9	4.8	0.5	0.0
Pueblo	4,685	80	86	25.35	30.02	+.03	57.2	+5.2	88	1	73	27	23	41	45	44	31	45	.17	−.5	1	6.5	nw.	24	s.	6	15	12	4	3.8	.0	.0
Concordia	1,392	50	58	28.57	30.03	.00	65.3	+9.4	96	4	80	25	23	51	52	51	41	49	.10	−1.9	2	9.0	s.	25	n.	22	21	10	0	2.2	.0	.0
Dodge City	2,509	10	86	27.45	30.03	+.01	63.6	+7.5	94	1	78	22	23	49	47	50	39	49	.18	−1.1	2	12.0	s.	28	s.	8	19	9	3	2.5	.0	.0
Wichita	1,358	85	93	28.62	30.04	+.01	67.0	+8.4	92	2	79	25	23	55	39	53	42	45	.16	−2.4	2	9.8	se.	23	s.	31	24	5	2	1.8	.0	.0
Oklahoma City	1,214	10	47	28.78	30.04	+.01	69.8	+8.3	97	1	83	31	23	57	38	55	44	48	.21	−2.6	2	8.5	s.	23	n.	22	21	8	2	2.6	.0	.0
Southern Slope							**67.8**	**+4.7**										**50**	**1.38**	**−0.5**										**2.7**		
Abilene	1,738	10	56	28.25	30.04	+.03	70.5	+5.1	97	2	84	38	23	57	36	56	46	51	1.26	−1.2	4	8.4	s.	22	se.	9	21	7	3	2.3	.0	.0
Amarillo	3,676	10	49	26.35	30.04	+.04	64.8	+7.1	90	1	77	38	20	52	37	50	39	48	3.06	+1.4	4	9.3	s.	23	se.	8	21	6	4	2.7	.0	.0
Del Rio	960	63	71	29.01	29.99	+.01	73.8	+3.8	95	1	86	44	24	62	32	59	50	49	.23	−1.6	2	8.5	se.	27	nw.	22	17	12	2	2.6	.0	.0
Roswell	3,566	75	85	26.43	30.02	+.06	62.2	+2.7	86	15	77	32	24	48	42	50	40	52	.96	−.5	6	7.2	s.	27	w.	31	19	8	4	3.1	.0	.0
Southern Plateau							**61.0**	**+1.5**										**44**	**0.44**	**−0.3**										**2.8**		
El Paso	3,778	82	101	26.22	29.95	+.03	68.6	+5.1	92	15	82	44	24	55	37	53	42	43	.19	−.6	4	6.8	e.	26	ne.	19	25	4	2	1.8	.0	.0
Albuquerque [1]	4,972	5	39	25.11	29.99	-----	57.6	+1.0	84	15	73	32	25	42	42	45	34	50	.63	−.2	3	7.2	n.	40	s.	16	17	12	2	3.1	T	.0
Santa Fe	7,013	38	53	23.35	30.04	+.08	53.2	+2.8	76	15	64	26	20	42	32	40	28	44	1.60	+.4	5	6.4	e.	20	se.	7	14	13	4	3.8	.0	.0
Flagstaff	6,907	10	59	23.40	29.96	+.04	47.0	+2.3	74	13	64	19	17	30	46	----	----	----	.51	−.9	4	8.1	nw.	29	sw.	15	11	17	3	----	T	.0
Phoenix	1,107	39	51	28.76	29.90	+.02	71.6	+1.0	98	1	87	42	17	56	38	55	42	38	T	−.5	0	4.7	e.	18	w.	7	17	10	4	3.5	.0	.0
Yuma	141	9	54	29.75	29.90	+.03	73.2	−.1	100	1	88	49	17	59	40	57	45	43	T	−.3	0	4.8	w.	19	n.	19	25	3	3	1.8	.0	.0
Independence	3,957	5	26	25.97	29.98	+.03	55.6	−1.9	78	1	70	30	17	42	38	43	29	----	.16	−.2	2	-----	s.	----	----	---	22	4	5	----	.0	.0
Middle Plateau							**51.4**	**+1.5**										**56**	**0.98**	**+0.3**										**4.2**		
Reno	4,527	61	76	25.49	30.03	+.04	50.6	−.2	78	12	64	27	17	38	42	42	34	58	.29	−.1	6	5.7	w.	25	sw.	2	13	9	9	4.5	T	.0
Tonopah	6,090	12	20	-----	-----	-----	51.0	-----	74	12	61	27	16	42	26	41	31	52	.66	-----	5	7.6	se.	29	nw.	16	----	----	----	3.4	1.0	.0
Winnemucca	4,344	18	56	25.63	30.02	−.03	50.0	+1.7	76	2	65	27	23	35	44	41	33	60	1.81	+1.2	8	7.4	ne.	25	w.	2	10	6	15	5.6	T	.0
Modena	5,473	10	43	24.65	29.98	+.02	48.8	+.8	74	1	64	26	21	34	43	40	31	59	1.54	+.8	7	9.4	sw.	35	sw.	15	14	11	6	3.8	T	.0
Salt Lake City [1]	4,227	32	46	25.76	30.00	−.01	54.0	-----	80	4	66	28	19	42	32	45	37	58	1.49	-----	6	9.7	se.	44	s.	4	14	9	8	4.5	T	.0
Grand Junction	4,602	60	68	25.43	30.01	+.02	56.4	+3.6	81	3	69	32	21	44	34	44	34	47	.30	−.6	5	6.9	se.	31	s.	16	16	9	6	3.7	.0	.0
Northern Plateau							**52.5**	**+2.6**										**65**	**1.18**	**+0.1**										**5.4**		
Baker	3,471	36	54	26.48	30.06	−.02	49.0	+2.4	76	1	61	23	18	36	40	43	36	64	.66	−.2	9	6.5	s.	30	sw.	2	10	6	15	6.0	T	.0
Boise	2,739	79	87	27.19	30.05	−.01	54.0	+2.9	81	2	64	34	18	43	35	47	41	67	1.68	+.4	10	4.9	se.	22	se.	2	12	4	15	5.5	T	.0
Pocatello [1]	4,477	60	68	25.51	30.03	−.01	49.8	-----	79	2	62	26	18	38	40	43	37	66	3.17	-----	11	7.3	w.	31	w.	2	13	4	14	5.4	.3	.0
Spokane	1,929	101	110	27.99	30.05	−.01	51.2	+2.9	78	1	61	27	17	41	35	45	39	65	.83	−.3	10	6.0	s.	25	s.	2	11	8	12	5.7	.0	.0
Walla Walla	991	57	65	28.96	30.03	−.04	55.1	+1.6	83	2	65	35	17	46	32	48	42	64	1.31	−.2	10	4.8	s.	24	w.	2	14	3	14	5.1	.0	.0
Yakima	1,076	58	67	28.88	30.03	-----	53.4	+3.2	78	1	65	33	18	42	33	47	40	64	1.41	+.8	8	4.8	nw.	24	s.	2	14	6	11	5.0	.0	.0
North Pacific Coast Region							**54.8**	**+2.4**										**76**	**3.90**	**+0.1**										**6.5**		
North Head	211	11	56	29.77	30.00	−.05	55.5	+2.6	78	20	61	44	15	50	24	52	50	84	6.65	+1.6	17	13.5	s.	48	s.	28	8	6	17	6.4	.0	.0
Seattle	125	90	321	29.86	30.00	−.05	55.0	+3.6	74	19	62	38	16	48	30	51	47	77	2.95	+.1	14	8.5	se.	34	sw.	28	7	11	13	6.4	.0	.0
Tacoma	194	172	201	29.80	30.01	−.03	53.2	+2.7	66	19	60	35	16	46	27	----	----	----	4.37	+1.0	15	6.6	s.	33	s.	12	2	11	18	7.3	.0	.0
Tatoosh Island	86	10	54	29.87	29.97	−.04	53.0	+3.1	64	23	57	43	13	49	15	50	48	83	7.52	−.6	15	14.9	e.	47	s.	10	8	6	17	6.2	.0	.0
Medford [1]	1,329	29	58	28.62	30.02	-----	54.2	+.5	80	20	68	27	16	41	43	48	41	68	.79	−.6	6	-----	nw.	----	----	---	12	5	14	5.5	.0	.0
Portland, Oreg.	154	68	106	29.85	30.01	−.05	57.2	+3.0	78	1	65	39	17	50	29	51	46	72	2.87	−.2	16	6.1	se.	22	s.	12	5	10	16	6.8	.0	.0
Roseburg	510	45	76	29.48	30.03	−.05	55.5	+1.6	80	1	66	31	17	45	42	51	46	75	2.12	−.5	10	3.6	nw.	15	s.	31	7	7	17	6.7	.0	.0
Middle Pacific Coast Region							**60.4**	**+0.1**										**68**	**2.41**	**+0.8**										**4.9**		
Eureka	60	72	88	29.97	30.04	−.02	55.6	+2.0	68	1	62	41	16	49	19	52	50	83	3.34	+1.0	9	6.4	se.	24	sw.	28	11	6	14	5.4	.0	.0
Redding [1]	722	20	34	-----	-----	-----	62.4	−1.9	83	20	72	41	16	53	28	53	44	55	3.68	+1.6	8	7.8	nw.	25	se.	2	15	6	10	4.8	.0	.0
Sacramento	66	92	115	29.92	29.99	.00	62.2	−.7	84	12	73	42	16	51	32	54	48	62	1.29	+.4	6	6.0	se.	18	sw.	31	15	9	7	4.2	.0	.0
San Francisco	155	112	132	29.83	30.00	−.01	61.6	+1.1	81	25	68	50	16	55	26	55	51	74	1.33	+.2	5	7.3	w.	28	w.	14	10	12	9	5.2	.0	.0
South Pacific Coast Region							**65.0**	**+0.6**										**65**	**0.31**	**−0.3**										**4.2**		
Fresno	327	97	105	29.64	29.99	+.03	64.6	+.6	89	1	77	44	18	52	36	54	45	55	.69	+.1	4	5.2	nw.	18	nw.	2	11	15	5	4.4	.0	.0
Los Angeles	338	159	191	29.62	29.98	+.03	66.7	+1.4	89	12	76	51	17	57	30	56	50	63	.01	−.7	1	5.4	sw.	15	n.	13	21	7	3	2.7	.0	.0
San Diego	87	62	70	29.88	29.97	+.02	63.6	−.1	82	13	71	47	17	57	24	58	54	76	.23	−.3	2	6.1	nw.	17	w.	16	12	12	7	4.7	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.82	29.90	-----	79.4	−.4	87	20	84	69	3	75	14	----	----	----	5.69	−.2	18	8.4	e.	29	e.	11	8	22	1	4.2	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	-----	-----	-----	-----	-----	----	----	----	----	----	----	----	----	----	----	-----	-----	----	-----	----	----	----	----	----	----	----	----	----	----
Cristobal	36	6	97	-----	-----	-----	-----	-----	----	----	----	----	----	----	----	----	----	----	-----	-----	----	-----	----	----	----	----	----	----	----	----	----	----
Alaska																																
Fairbanks	454	11	87	[2] 29.03	[2] 29.54	-----	37.8	+11.5	61	20	46	11	29	30	29	36	31	76	.10	−.6	4	5.6	ne.	27	n.	17	2	9	20	7.6	1.2	.1
Juneau	80	96	116	[2] 29.65	[2] 29.74	-----	48.3	+5.1	64	19	53	36	14	44	22	44	40	74	9.90	−1.0	24	9.4	se.	30	e.	17	2	5	24	8.8	.0	.0
Nome	22	5	32	[2] 29.47	[2] 29.49	-----	33.6	+4.6	52	5	39	11	30	28	20	33	31	82	1.06	−.3	15	8.1	ne.	25	n.	17	1	6	24	8.7	4.4	1.2
Hawaiian Islands																																
Honolulu	38	86	100	29.97	30.01	-----	77.6	+.8	85	1	82	67	15	73	15	71	68	72	1.33	−.2	12	8.7	e.	28	ne.	15	8	19	4	4.9	.0	.0

[1] Observations taken at airport.
[2] Pressure not reduced to a mean of 24 hours.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, October 1938*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Mean maximum	Temperature: Mean minimum	Temperature: Highest	Temperature: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				47.8	+2.0	54.8	40.7	64	31	6.72	+3.37	0.0
Sydney, Cape Breton Island	48	29.89	30.02	+0.07	51.2	+3.4	59.2	43.2	78	30	4.83	+.28	.0
Halifax, Nova Scotia	88	29.79	30.06	+.04	52.3	+3.6	58.6	46.0	75	34	4.68	−.54	.0
Yarmouth, Nova Scotia	65	29.95	30.06	+.03	51.2	+2.4	58.9	43.5	71	33	2.76	−1.37	.0
Charlottetown, Prince Edward Island	38	29.97	30.05	+.07	49.6	+1.8	56.4	42.9	74	30	2.35	−1.95	.0
Chatham, New Brunswick	28	29.93	30.04	+.05	47.0	+1.7	56.9	37.0	81	34	2.65	−1.33	.0
Father Point, Quebec	20				42.4	+2.0	49.4	35.5	66	20	1.25	−2.02	.0
Quebec, Quebec	296	29.75	30.08	+.07	48.0	+4.5	55.2	40.8	75	30	1.97	−1.50	.0
Doucet, Quebec	1,236	28.74	30.12	+.09	41.0	+3.0	51.6	30.5	70	15	2.33	−1.43	T
Montreal, Quebec	187	29.89	30.11	+.09	50.5	+3.9	57.7	43.2	77	30	1.22	−2.06	.0
Ottawa, Ontario	236	29.85	30.11	+.07	47.5	+1.7	58.4	36.6	81	24	.46	−3.02	.0
Kingston, Ontario	285	29.80	30.12	+.08	51.0	+2.6	58.3	43.8	71	31	.72	−2.28	.0
Toronto, Ontario	379	29.72	30.14	+.08	52.1	+3.7	60.4	43.8	82	33	1.03	−1.40	.0
Cochrane, Ontario	930	29.04	30.08	+.07	43.2	+4.1	51.6	34.9	78	22	1.24	−1.38	1.2
White River, Ontario	1,244	28.72	30.09	+.09	41.8	+3.7	51.9	31.7	78	16	1.45	−1.12	.1
London, Ontario	808	29.24	30.13	+.07	50.2	+2.0	61.9	38.4	82	25	1.18	−1.64	.0
Southampton, Ontario	656	29.40	30.12	+.09	50.0	+2.0	59.7	40.4	81	25	1.28	−1.92	.0
Parry Sound, Ontario	688	29.42	30.12	+.09	49.5	+3.3	58.2	40.8	79	28	2.21	−1.79	.0
Port Arthur, Ontario	644	29.32	30.04	+.04	44.7	+2.9	53.8	35.6	71	23	1.30	−1.15	.0
Winnipeg, Manitoba	760	29.12	30.60	−.01	48.5	+7.4	59.6	37.4	82	21	.40	−1.08	1.5
Monnedosa, Manitoba	1,690	28.18	30.02	+.03	45.8	+5.6	57.4	34.3	79	19	.81	−.29	7.1
Le Pas, Manitoba	860	28.96	29.95	+.02	44.6	+10.5	57.4	31.7	75	17	.86	−.24	.0
Qu'Appelle, Saskatchewan	2,115	27.71	30.01	+.01	47.6	+7.4	59.0	36.1	76	23	.52	−.61	.0
Moose Jaw, Saskatchewan	1,759	28.00	30.01	+.04	49.5	+8.3	61.2	37.8	80	24	.61	−.20	1.5
Swift Current, Saskatchewan	2,392	27.17	30.01	+.01	48.1	+6.1	59.3	36.9	76	23	.85	+.05	1.8
Medicine Hat, Alberta	2,365	27.48	30.00	+.03	48.3	+3.0	62.3	34.3	78	17	.91	+.32	.0
Calgary, Alberta	3,540	26.32	30.02	+.03	45.6	+3.7	58.2	33.1	74	19	.97	+.32	T
Banff, Alberta	4,521	25.34	29.94	−.06	41.7	+3.0	54.4	29.0	67	12	1.14	+.05	T
Prince Albert, Saskatchewan	1,450	28.41	29.97	−.01	45.0	+6.4	54.7	35.3	70	22	2.04	+1.10	.0
Battleford, Saskatchewan	1,592	28.23	29.98	.00	45.6	+5.6	57.3	33.8	73	20	1.14	+.55	.0
Edmonton, Alberta	2,150	27.66	29.96	+.04	44.6	+3.8	56.5	32.7	72	22	.01	+.20	.5
Kamloops, British Columbia	1,262												
Victoria, British Columbia	230	29.75	30.01	−.03	51.6	+1.2	57.2	46.1	65	39	2.61	−.11	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170	29.63	29.82	−.07	49.8	+2.6	55.8	43.7	69	36	9.27	−3.05	.0
St. George's, Bermuda	158		29.97	−.05	75.8	+2.2	81.3	70.3	86	62	10.19	+3.88	.0
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Cape Race, Newfoundland	99				57.2	+4.4	62.7	51.6	70	36	2.99	−0.60	0.0
Montreal, Quebec	187	29.82	30.02	−0.01	56.6	−2.1	63.3	49.9	75	37	6.44	−2.90	.0
Banff, Alberta	4,521	25.44	29.98	−.01	55.2	+8.2	72.7	37.7	86	30	.80	−.93	.0

TABLE 4.—*Severe local storms, October 1938*

[Compiled by Martha J. Gallenne from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Easley, S. C. and vicinity	6	3:40 p. m.	[1] 2		$7,500	Heavy hail	Crop loss principally to cotton, fall gardens, and flowers.
Carlsbad, N. Mex	9	4:30 p. m.	440	6	30,850	Tornadic winds	No details.
Clovis, N. Mex	9	7 p. m.	1–5		2,500	Hail	Damage to farm buildings and matured crops.
Helena, Mont., and vicinities	15–18			1	18,000	Snow	In the vicinity of Butte, Mont., a woman froze to death after becoming lost in the snow. Several hunters lost for days before finding their way to shelter or being located by searching parties. Heavy damage to trees.
Minnesota, extreme southeastern counties.	22				100,000	Sleet, snow, and wind.	Sleet and moist snow clung to wires and trees; motor traffic delayed. Greatest damage in vicinity of Red Wing, which was practically isolated, with factories forced to shut down because of lack of electric power.
Michigan, Upper Peninsula	22–23					Snowstorm and strong winds.	Considerable damage especially to small craft and fishing equipment in northern Lake Michigan. Ferry service suspended at the Straits of Mackinac because of high seas.
Wisconsin, northern portion [2]	22–23					Blizzard	Light and telephone service disrupted. Automobile travel halted. At Manitowoc, Wis., a heavy sea undermined an old lighthouse marking the harbor pierhead and toppled it into shallow water.

[1] Miles instead of yards.

[2] From press reports.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, October 1938

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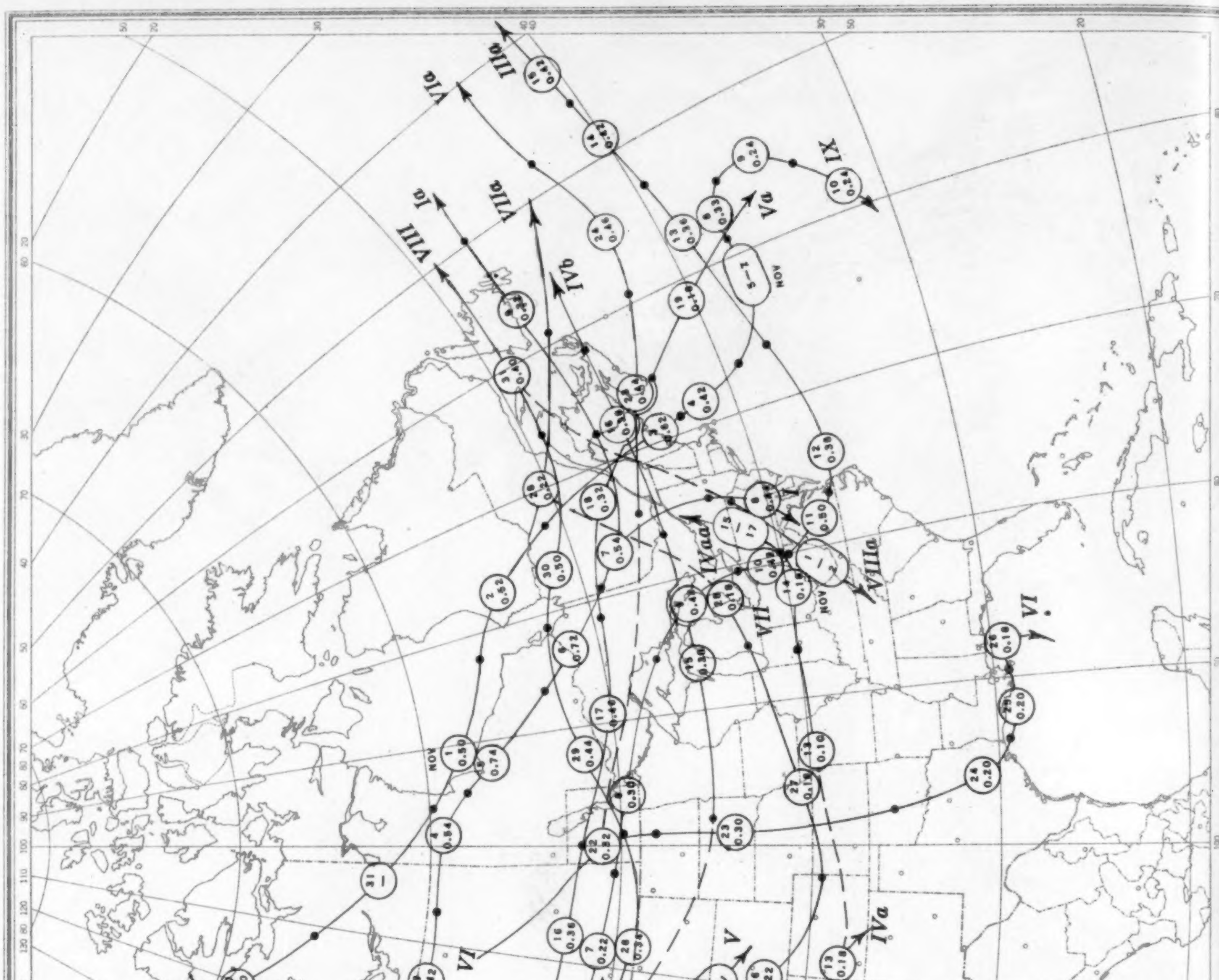
Chart II. Tracks of Centers of Anticyclones, October 1938. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, October 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

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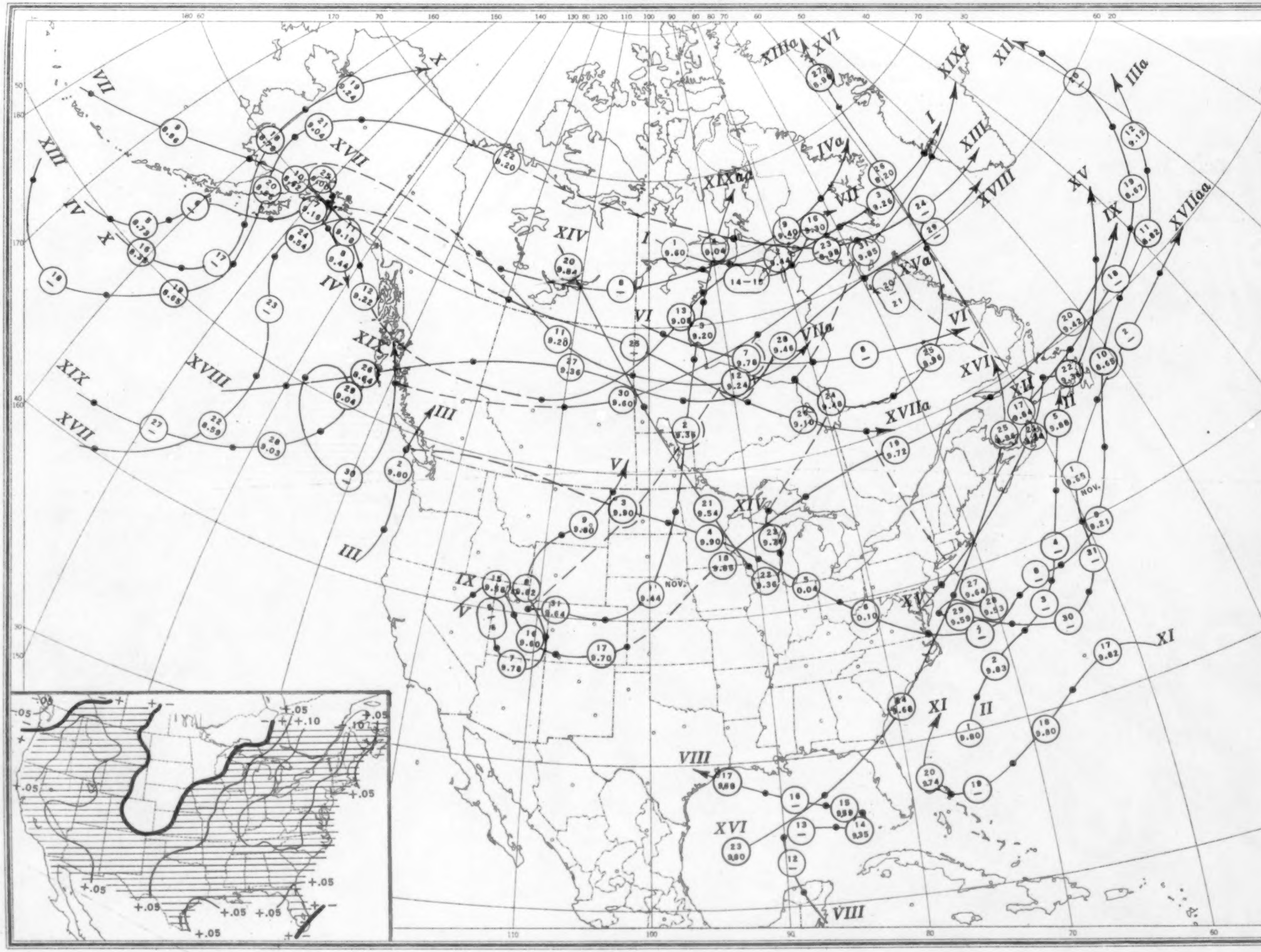
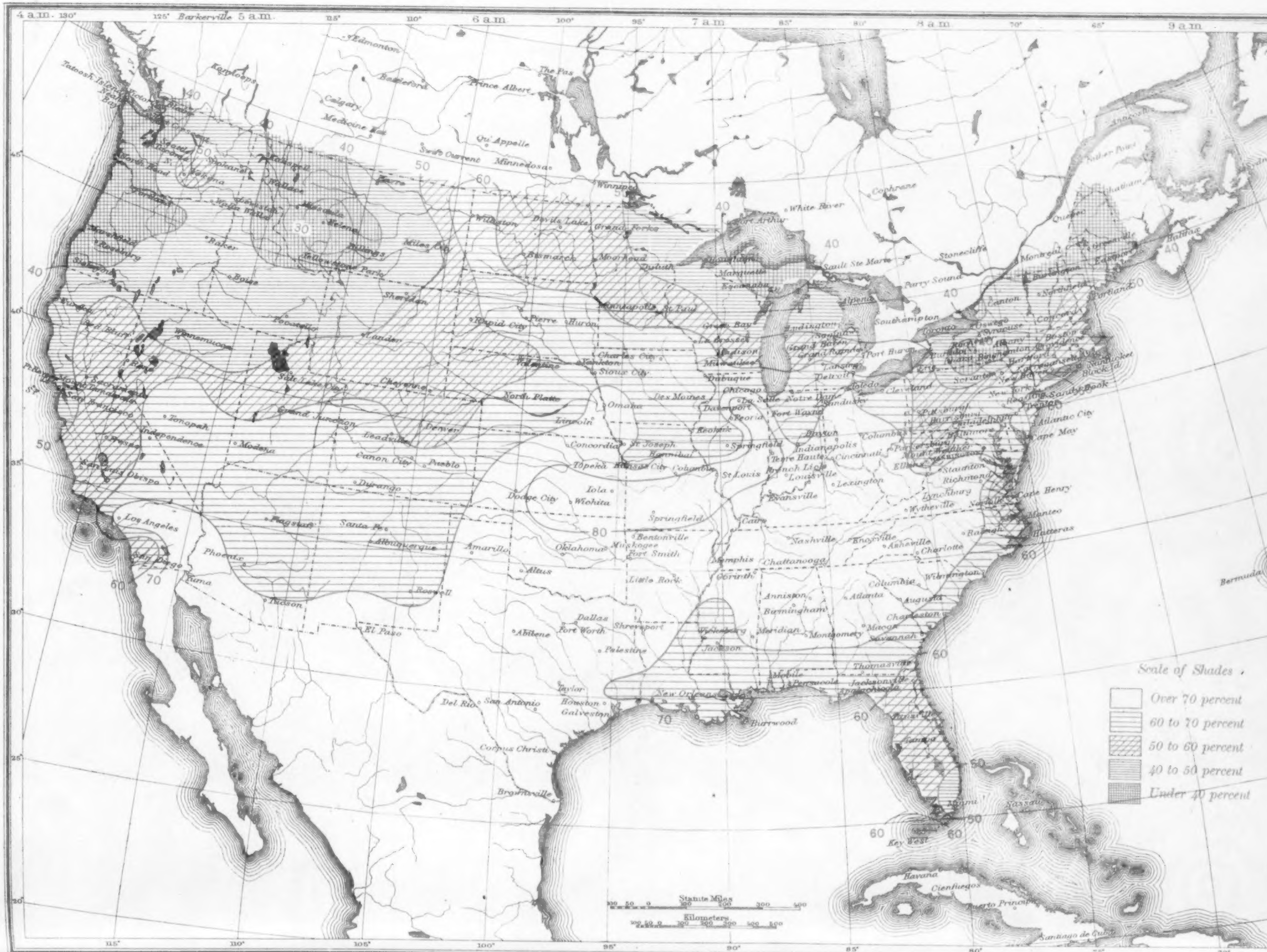
(Plotted by W. P. Day)



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time)

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, October 1938



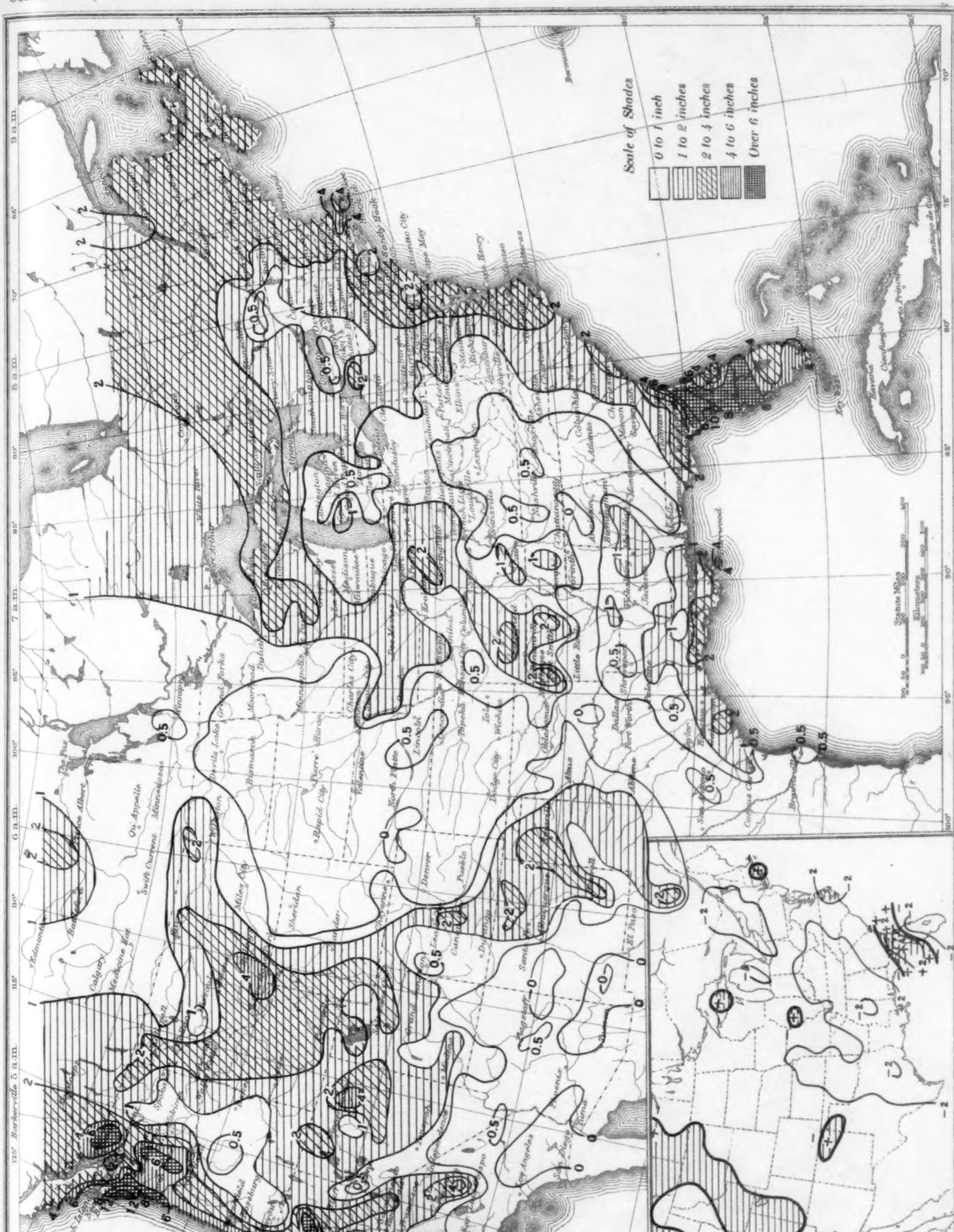


Chart V. Total Precipitation, Inches, October 1938. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, October 1938

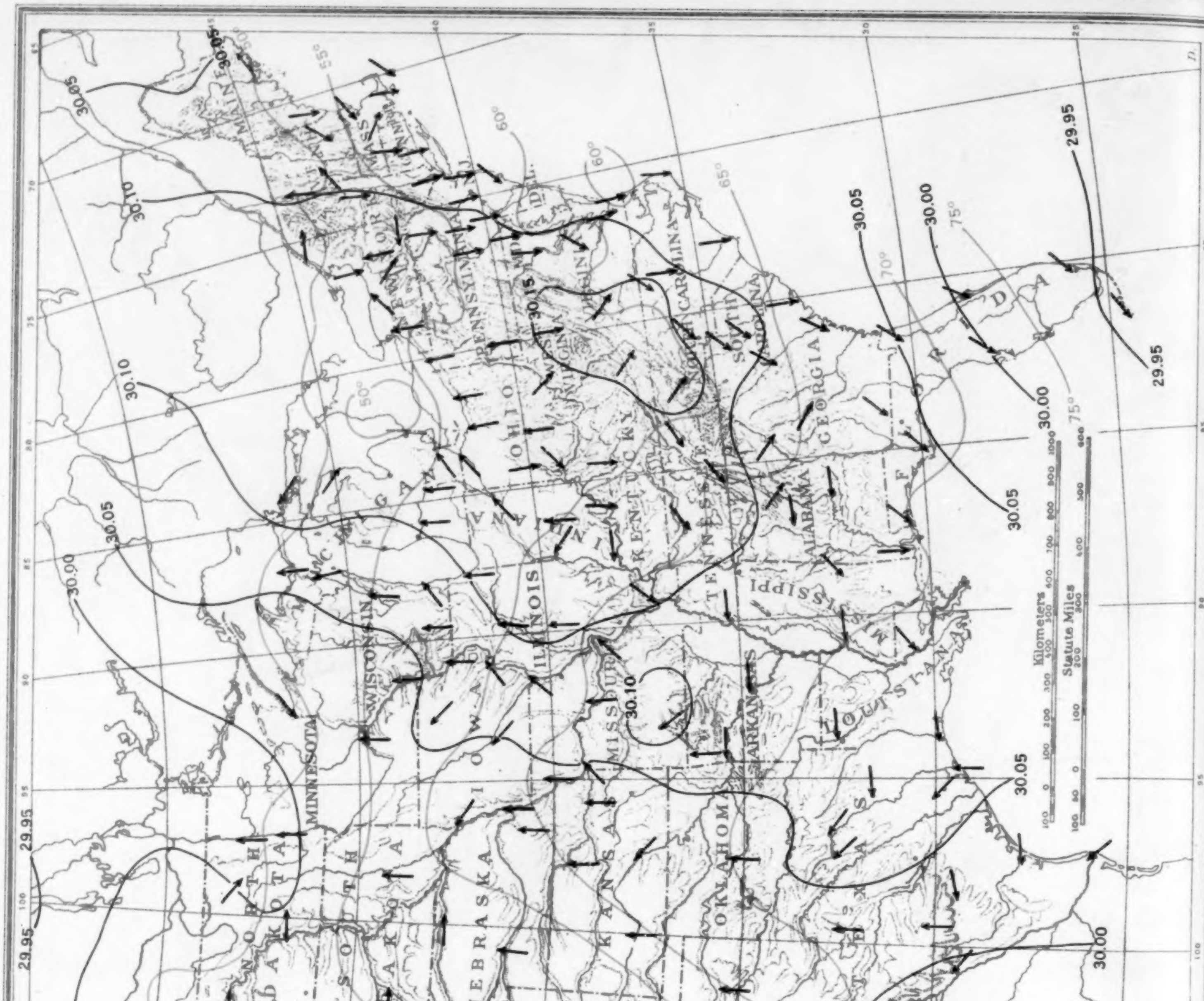
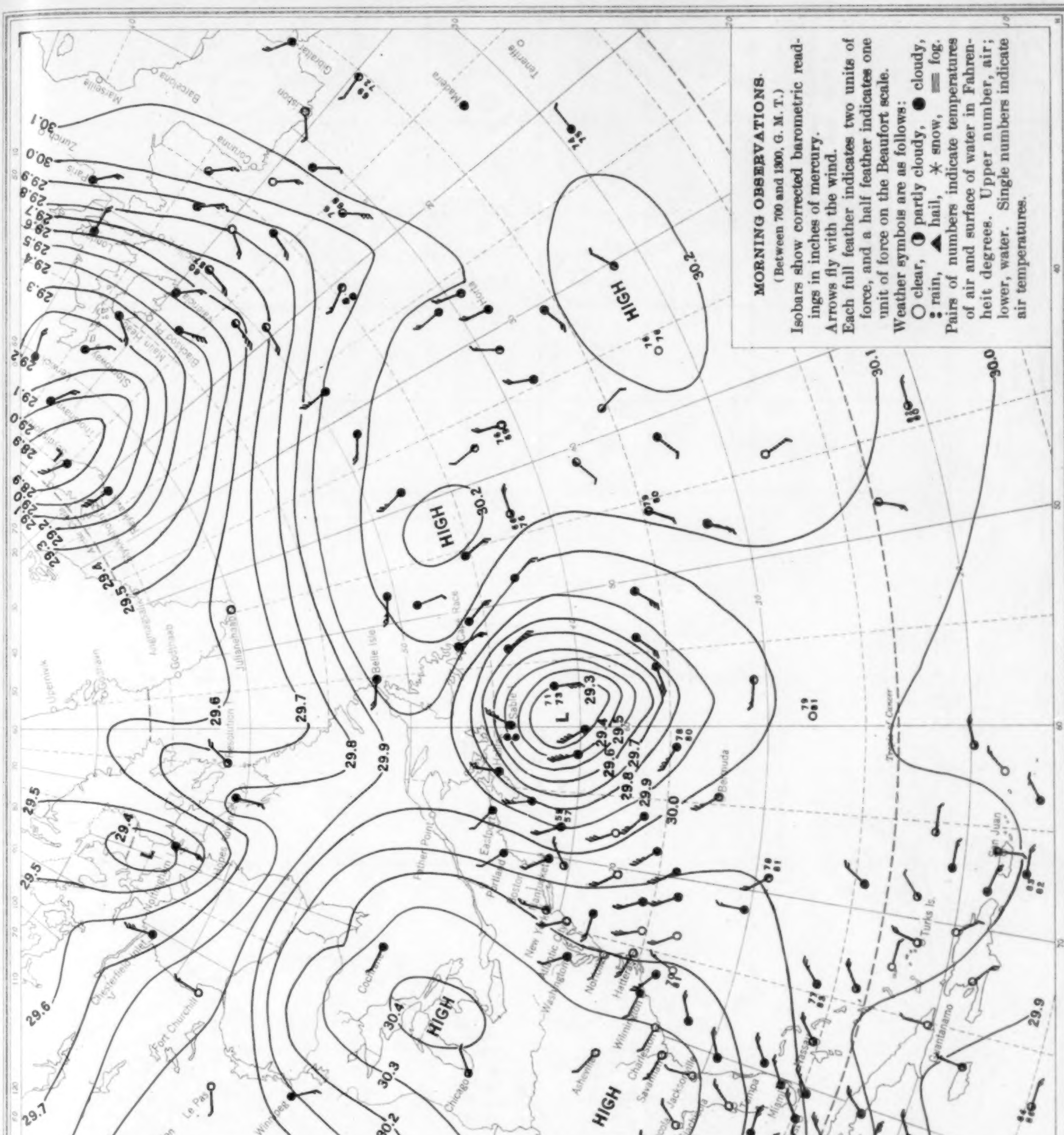


Chart VII. Wind Roses for Selected Stations, October 1938
(Plotted by J. P. Kohler)

(Plotted from the Weather Bureau Northern Hemisphere Chart)



(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Tracks of Centers of Tropical Disturbances, October 1938
(Plotted by J. H. Gallenne)

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(Plotted by J. H. Gallenne)